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The Care and Cultivation of Muck Farms

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Peat lands, which, till within a few years, have been chiefly ignored for farming purposes, are now known to be the most profitable agricultural lands that we have. They are the richest, the easiest to cultivate, and the best supplied with water, an abundance of water having been necessary for their formation.

A discussion of the best methods for operating a muck farm should probably begin with the clearing and drainage of the land. Of these two preliminary operations, the digging of the main drainage canal is first in importance, as it facilitates the clearing. This canal should be capable of carrying away all the excess water as fast as it accumulates over the farm and is conveyed to the canal by the small ditches. Otherwise the water will stand on the growing crops in unusually wet seasons, and quickly destroy them.

The clearing away of the timber and undergrowth, if it is strongly rooted, is by far the most expensive item in opening up a tract of muck, but as it has to be done only once, it should be done with an eye to the future, and the use of exceedingly destructive clearing fires should be avoided as much as possible, as they are liable to get beyond control and burn off 1 to 3 feet of the soil. The use of dynamite under stumps, and teams and engines for pulling them out, will be a good investment in the long run, for though the burning method is cheaper and quicker at the time, the loss of the top layers of muck is of much more consequence than the increase in expense when clearing without fires that burn the ground. The brush should be cut and piled, and the stumps and logs also piled, and burned when the ground is sufficiently wet so that the fires will not work down into it. Because of the lightness in weight of the muck soils, causing a certain quantity to blow away every spring before the vegetation is high enough to hold them during the high winds, and also because of

*Read at the Detroit meeting, September, 1915.

the apparent oxidation of certain constituents of the soil during each year's cultivation, by the combined action of the sun and air, the thickness of a layer of muck under cultivation seems to steadily decrease, frequently at the rate of an inch or two per year. This being the case, the loss from bad fires would be very serious, where the muck layer is only a few feet in thickness.

After providing the main canal. the purpose of which is to carry the surplus water off the farm, smaller drains should be dug parallel to the main canal and emptying into a single lateral at the lower end of the farm. This arrangement will permit the working of the farm in long fields, doing away with much of the turning necessary where the farm is cut up by many ditches running at right angles. Also, if the buildings are near the center of the farm, as they should be for the greatest saving in time in reaching the different fields, any one of the long fields may be reached in the minimum time from the buildings, and the team or machine started to work from the main road, with the least loss of time. This arrangement also makes it possible to dyke the main canal in through the entire length of the farm and in some cases thus avoid disastrous flooding. Where the land is not tile drained, it is well to have the small drains an eighth of a mile apart, tile or small culverts being placed in them at intervals of a half a mile to make crossings for teams. The small drains should be about 3 feet deep, and just wide enough so that they can be kept clear of obstructions and clean.

Tile draining in muck land appears to be very beneficial, but as the expense is considerable it is usually placed at first only in the ground that is especially cold and wet. The usual method is to lay 4-inch common drain tile in parallel lines about 5 or 6 rods apart, at a depth of 3 or 4 feet below the surface. Such tile cost about $18 per 1,000 linear feet, freight paid, in Michigan. About four hundred and fifty linear feet of tile per acre drained will be required, so that the cost is about $8 per acre for the tile. The trench for the tile must be dug to grade and have an outlet lower than the grade. The digging usually costs 15 to 25 cents per rod, or $4 to $7 per acre. The outlet is usually an open drain, which should be cleaned once a year, the ends of the tile drains being cleaned out at the same time. If a machine is used for digging the trench it should have a sighting and depth-regulating equipment, making digging to grade an easy matter. If the work is done by hand, however it will be necessary to back the water up to the level of the tile and obtain the grade from the level of the water, or else to use a surveyor's level.

Last in importance in fitting out a muck farm are the buildings, as temporary, rough shelters will do at the beginning. Buildings should be as near the center of the farm as possible, and though they should be built as cheaply and economically as possible for fulfilling their special requirements, they should provide warm and dry shelter for the horses and other stock, protection for the tools and machines from snow, rain, and sun, and

comfortable and decent shelter for the employees. The first two are indispensable for the economical operation and maintenance of the farm, and the comfortable and neat-appearing houses will prove a good investment in insuring an easier labor supply and bringing a better class of help to the farm.

As early as possible in the development of a muck farm, it is highly advisable to lay out a series of windbrakes at intervals of a quarter of a mile, parallel to the ditches, and far enough away from ditches so that they will not interfere with keeping the ditches clean and so that the dirt thrown up will not be piled against the trees. There should also be windbreaks set out at right angles to these at the upper and lower end of the farm, and along the main road. These windbreaks may be made with a single row of trees planted about 6 feet apart in the row. They should be evergreen trees so that they will have their foliage in the spring when it is needed most. The white cedar or arbor vitae seems to be the most suitable evergreen, and the elm the most suitable deciduous tree. In the course of years these will become very valuable for preventing the blowing of the soil and the flattening of crops under heavy winds.

Though the profits from the different crops vary greatly, depending on the gross returns and total labor expense, and cost of materials, as fertilizer, seed, etc., there are a few chief operations that are common to all crops. In general the ground is plowed once every time it is planted. This should be the rule, though slack farmers sometimes plant without plowing. Marcus Cato, the famous Roman, wrote a classical treatise on farming and said that the most important thing after plowing was to plow again, and he was much nearer right than the farmers that slight their plowing. It is very desirable that the plowing be done in the fall rather than in the spring, as the spring-plowed muck soil has a tendency to bake, on account of the numerous fibers it contains, held together by the gluey humus. When plowed in the fall, however, the winter frosts thoroughly disintegrate this fibrous mass and pulverize it. The exposure during the winter and spring also areates and ventilates it, overcoming a sourness and rawness which is liable to be prevalent in the spring-plowed ground.

The plowing should be 8 or 10 inches deep for truck crops or most other crops, as the plowing depth determines the depth to which the soil will be capable of feeding the roots. After the plowing and before the spring planting, the soil should always be thoroughly worked up with disking harrows or toothed harrows, in order to give it additional ventilation and to check any weed growth that may be starting. The chief importance of this harrowing and of subsequent cultivation is due to the necessity that the plant roots be able to breathe pure air, which has to be worked into the soil in this manner. During the course of the harrowing, between the plowing and the planting, is usually the time for the first application of fertilizer, which may be followed later with

one or more further applications. Chemical fertilizers are usually sown broadcast with special drills, of which there are a number of different makes on the market, some much better than others.

Of all the important principles of modern agriculture, fertilizing seems to be one of the least appreciated by American farmers in general. It is largely because of their more extensive use of chemical fertilizers that European farmers get so much larger yields than we do. To a certain extent the continual dissolution to the rock particles in the soil replenishes the chemical fertility of some soils, as the fertility is reduced by the crops that are removed and sold. This is not true of muck soils, however, as they are all organic matter and there is no rock going into solution in them. Therefore the best system for the fertilization of muck soils is to each year put back into the ground the same quantities of the essential elements of plant food that are removed. In this way you will retain the original fertility in your soil, which is well worth the cost. The thought may come to some that, though such a method might do now, while the world is well stocked with mineral fertilizers, nitrate beds in Chili, and potash mines in Europe, and an abundance of phosphate rock all over the world, the problem of maintaining soil fertility will become difficult after these mines have been exhausted.

As a matter of fact, however, all danger of a nitrate famine is being removed by the exceedingly rapid development and extension of the electrochemical process of nitrate manufacture, in which cheap and abundant electric-power supplies, such as exist in Scandinavia and many other parts of the world, are used to burn nitrogen in air under the heat of the electric arc, nitrate being the final product, the cost of manufacture being well below the market price of Chili nitrate. As to potash, there have been new deposits of seemingly exhaustless extent discovered in Alsace-Lorraine, but even assuming that all the potash mines in the world will one day be exhausted, we have in this country, or rather along the Pacific Coast, a source of potash sufficient to afford us a continual supply at a cost below the price prevailing before the war, the present market price being prohibitive for agricultural use. This great and important source is in the great kelp beds. Kelp is a seaweed which secures itself to rocks or shore and grows in dense masses several feet in depth and sometimes several miles in width, extending up and down the coast in various places. Though the utilization of it for potash is scarcely more than experimental as yet, as the potash famine in this country is only about a year old, the method of utilizing it is as follows: A large floating mowing machine cutting a horizontal strip about 10 or 12 feet wide, about 3 feet under the water, and with vertical knives on each side, the horizontal cutters being power driven, is hauled along by a tug equipped with knife-edged propellers, which do not tangle in the seaweed. In the body of the cutting machine is an endless belt which carries

the cut kelp to a barge in the rear, capable of holding 30 to 50 tons of the wet kelp. The load is then towed to the manufacturing plant, where the kelp is first put through a press to squeeze out the excess water; then cut into pieces and run through a cylindrical drier, from which it issues thoroughly dried. It is then put into large retorts and charred at a certain definite temperature, creasote being a by-product of this stage. The charred kelp is then leached and the resultant solution concentrated by evaporation and crystallized, the potash obtained amounting to about 25 per cent of the weight of the charred kelp. Iodine is a by-product of the process, its separation costing 16 cents per pound, the market price being about $5 per pound. When cut off in this way, the kelp renews itself completely in three months, so that it affords a continual means of supplying our entire requirements in potash from that inexhaustible and everlasting source, the sea.

Books on agricultural chemistry and bulletins of the United States Department of Agriculture and of the agricultural college experiment stations, as well as printed matter issued by fertilizer manufacturers and jobbers, state the amount of the essential plant food that is removed by the different crops. Sugar beets, for instance, at a yield of 15 to 20 tons per acre, remove as much potassium from an acre of ground as is contained in 225 to 300 pounds of muriate of potash, worth from $4.50 to $6 at prices current before the war started. A ton of sugar beets in Michigan is worth $6, so that a farmer raising 20 tons per acre should figure to put one ton per acre back into the soil in the form of muriate or sulphate of potash. It is better to put back a little more than the theoretical amount, in order to make up for the losses from the leaching of the soil.

The three most essential elements of plant food are nitrogen, potash, and phosphoric acid. The first is obtained chiefly in the form of Chili saltpetre, but is comparatively abundant in muck land, having been deposited in the soil through many centuries by many different kinds of leguminous plants growing in it and eventually becoming a part of it. This usually costs between $50 and $60 per ton. In muck farming it is used chiefly for producing rapid growth and forcing growth through bad periods, as table vegetables generally have to grow continuously in order to have a mild flavor. As nitrate of soda is immediately absorbed by the plant, it is often sprayed onto the soil at intervals of two weeks or a month.

Phosphoric acid is supplied commercially from rock phosphate and from dissolved bone. The latter contains more phosphoric acid in available form, but the rock lasts through a greater period of years, as the soil acids continually dissolve it and so render it available. In buying a phosphate fertilizer you should be sure that there is as large a percentage of available phosphoric acid in it as you are paying for. The form of potash chiefly used is the muriate, but the sulphate, which costs about

the same, improves the flavor of some crops, and is preferred for sugar beets on account of the chemical effects of the chlorine of the muriate during the process of sugar manufacture. The soil should also be kept well supplied with lime in the form of ground limestone or marl, as a certain amount of this is necessary to correct acidity. Where marl beds underlie the muck, liming may not be necessary, but the best method of determining whether it is needed is to sow from one-half ton to a ton per acre over a few acres and compare the results with those where lime is not applied. Limestone or marl can usually be purchased at 50 cents to $1.50 per ton at the deposits or grinding mills, and is generally applied liberally, when used, so that the application will last through three or four years.

After the completion of the fertilizing and subsequent harrowing, the ground is ready for planting, being well drained, and yet well stocked with moisture, well fertilized, well pulverized so that the rootlets can easily make their way through it, and well aired and ventilated so that the rootlets can breathe plenty of pure air in the course of their development.

Relative to the choice of crops for any particular piece of ground, there is one very important consideration that cannot be overlooked without expensive loss of time, labor, and material. This is, that the same land must not be in the same crop all the time, but that the farm must be operated under a definite system of crop rotation, flexible, perhaps, but systematic. Whether onions, or celery, or sugar beets, or cabbage, or all, or none be the specialty, there must be a certain fraction of the farm in other crops than any single specialty, each year, so that within a certain period of years, say three to five years, according to the special circumstances, every portion of the farm will have spent one or two years in other crops than the specialty. Where this principle is neglected for any long period of years, the inferiority of the product in spite of lavish fertilizering and cultivation, and the prevalence of soil diseases and pests, will clearly prove its importance. In order to conduct this rotation in as systematic a manner as possible, it is a very good plan to make a rough sketch map of the farm, making several carbon impression, and using one map for each year for several years in advance, make a general scheme for the rotation of the crops, subject each year, of course, to choice among a few crops for any particular piece of ground, but so planned that two crops subject to the same diseases, and breeding the same pests, will not be planted on the same ground more than two years in succession. Relative to the choice of truck crops for any particular year, it has seemed to be the rule that the most profitable year for a crop that is subject to large market fluctuations and is easy to go into and to discontinue, as onions or potatoes, is the year following a season of discouragingly low price. There is an old rule among farmers that the best year to plant potatoes is the year when the seed potatoes are given away. After such

a year growers seem to be generally discouraged and plant lightly, whereas, after a year of good price, the temptation to plant heavily is too great to be resisted by a large majority of growers; hence the resulting crop is excessively large, and the profits are correspondingly small.

Relative to the particular methods for raising the various important muck crops, the first of the crops to be planted in the spring is the onion. This should be planted as early as the ground can be fitted. The ground should be plowed deep the preceding fall, and disked and harrowed as soon as the frost is out in the spring, being fertilized at the same time. After the coarse harrowing it is harrowed with a fine-toothed, comb-like harrow, which picks up all the brush and sticks that if left, would interfere with the planting and cultivation. It is then floated with a light wooden float, the horses wearing broad wooden shoes called muck shoes, clamped on over the hoofs so that they will not punch holes in the ground, into which the planting drill might drop, causing irregularity in the planting. The seed is then sown with a hand drill at the rate of 3¾ to 5 pounds per acre, in rows 12 to 14 inches apart. If a fairly large acreage is to be planted, needing several planters, they usually work across the field in a diagonal line. Onion seed costs usually about $1.25 to $1.50 per pound, and it is very important to know that it has been properly grown from select bulbs, as inferior onion seed is liable to produce a large proportion of thick necked and bad shaped onions. The thick necked onions are called scullions and do not keep well. As soon as the crop is started it should be cultivated with a hand cultivator, and weeded by hand, and thereafter cultivated at least once a week and weeded as often as the weeds become numerous, which will depend on the thoroughness of the previous eradication of weeds on the land. In the early fall when the tops have died down, the onions are pulled and laid in rows on the top of the ground, and after being left exposed for a day or two, the dried tops are sheared off a half inch above the bulb and the onions are put in crates and the crates piled up in the field, the lower ones standing on some rough boards, to give ventilation, or put under cover. If left outdoors they should be covered with canvas during rain. Just before being put into crates the onions are generally sorted by being worked over on a screening table having bars at a distance apart corresponding to the diameter of the smallest normal onion. This removes the most of the smaller onions as well as the dirt and litter. Before the freezing weather comes on, the onions must be either sold or placed in covered storage.

The cultivation of celery on a large scale is carried on chiefly for the production of late celery, as early celery must be moved quickly and its handling involves a great amount of detail. For late celery the seed is sown early in the spring in open beds by scattering it over the surface and lightly raking it in. One

ounce of seed will make a narrow bed about 200 feet long, or enough plants for ¼ to ½ acre. As soon as the plants are big enough, usually beginning about the middle of June, they are set out in rows 4½ or 5 feet apart, and about 6 inches apart in the row. Frequent cultivation should be given throughout the growing season. As soon as the ground is thoroughly cooled in the fall, which is usually in the latter part of September, the dirt between the rows is banked up against the stalks with a horse-drawn implement called a banker. The celery is banked three times at intervals of about 10 days or two weeks, the height of the banks being increased each time, until at the end of the last banking it is up to the lower part of the foliage. Within about three weeks of the last banking the celery will be bleached ready for shipment. The statement made above about the importance of steady growth is particularly true of celery, and if the season is cold and backward, the ground should be sprayed with nitrate to force the growth, so that it will be mild and tender. Celery is usually shipped in the rough, without washing, as it keeps better that way, the dead or unbleached stalks on the outside being picked off in the field as it is harvested. It is usually shipped in crates about 22 inches square, of a height corresponding to the height of the stalks, usually 18 or 20 inches. When made 22 inches square they may be set four wide in an ordinary refrigerator car. The crates are made from cheap lumber, three slats on a side and three on the bottom. The two upper slats on one side are left loose at one end and not nailed until the celery has been put in. The crates are placed upright in the refrigerator car in tiers, ventilating space being left around the sides of the car. If the celery cannot all be shipped when ripe it is placed upright in trenches about a yard wide, high enough so that it will be well drained, and the earth banked up around the sides of the trench, level with the tops. In this shape it will endure a considerable amount of cold weather.

Cabbage is also a transplanted crop, the seeds being sown about the first of June, with a hand drill, in rows about 10 inches apart, the drill being so regulated as to space the seeds about an inch apart in the row. It will take about 2 ounces of seed to supply enough plants for one acre of cabbage. When the seedlings are three or four weeks old, or three or four inches in height, they are transplanted in rows three feet apart, and placed 18 inches to 2 feet apart in the row. There are two varieties in extensive cultivation, the Danish Ball Head, preferred for winter storage, and the Domestic, preferred for the manufacture of sauerkraut, which has been made quite an industry in cabbage growing districts. Muck ground is excellent for cabbage, and as a rotation crop cabbage is excellent for muck ground.

The various mints are grown almost exclusively on muck land. Though this crop is confined to a few districts for its main production, it is nevertheless important as a muck crop.

The mint plants are proprogated entirely from runners pulled from the old roots in the spring, these runners being laid in a continuance string in trenches 3 feet apart. This is done as early as possible in the spring, and the usual weeding and cultivation given later. The plants are cut when in blossom and the oil distilled off, the straw being dried for cattle feed, or composted and put back onto the soil.

Sugar beets grow very heavily on muck land, though with a smaller percentage of sugar than on high land. They are a profitable crop, however, for localities near the factories, or with good shipping facilities, and are good for the land, as they send tap roots deep into the ground, which leave channels when they decay, allowing the water to drain away more readily in wet weather and drawing it up in dry weather. They should be planted about the 5th to the 15th of May in districts where corn is planted about the 15th, or, in general, about ten days before corn-planting time. Twenty-four inches is a good distance apart for the rows. Sugar beets are not transplanted, like celery and cabbage, but are sown thick in the permanent rows and thinned out to about 8 inches apart when the second pair of leaves appears, or as soon after that as possible. About 15 pounds of seed per acre is necessary for a good stand. It is well to let out on contract all the hand labor, the usual rate being about $18 per acre.

Of intensive farming in general, it may be said that there is probably no business which requires more thoroughness in preparation and providing ways and means in advance, as the seasons are uncertain at best and with no man's convenience. It is well to not only have a definite scheme for the planting before the year's work opens up, but to see that seed, fertilizer, hand tools, horse implements, etc., are as far as possible all provided for in advance. This method requires a lot of foresight until a farm is well established and under way, but it is the only method that makes for efficiency in farming and the obtaining of satisfactory results.

Agricultural Possibilities of Ohio Peat Soils

By Alfred Dachnowski *

The agricultural profit from peat and muck soils in Ohio as well as in the neighboring Lake States depends on several considerations, and every reasonable means should be employed to make the information concerning them trustworthy and practicable. The most essential requirements are (1) a careful study and description of the different individual peat and muck soil types and their local conditions that give rise to the different degrees of crop productivity and thus determine the land value, (2) a tabulation of the actual experiences and results secured from definite field trials with different systems of soil improvement and crop systems, and (3) biological studies relating to extension of the range of crops suitable to the several types of peat and muck soil. These considerations are fundamental and must furnish the post necessary information as to the possibilities of these soils as to the preservation of their crop and land value. These considerations involved in any adequate effort to co-ordinate and encourage peat and muck-land agriculture, or in a discussion of the general principles of developing and improving the peat resources of this country.

The fact that all peat soils are not adapted to the same kind or variety of crop, do not require the same kind of fertilizer treatment or drainage, and are not suited to the same system of crop rotation is not generally so well understood and admitted in practice as experience and experiments justify. A knowledge of the different types of muck and peat soil becomes therefore essential. Sufficient data have now been collected in Ohio relating to the location, the origin, and the formation of peat and muck to serve as a basis for effective agricultural practice. (Ohio Geol. Survey; Bull. 16, 1913).

Characteristics of a Productive Type of Peat Soil.

In establishing peat and muck land types the several methods now in use have their advantage, but revision will undoubtedly take place as our knowledge increases. In the writer's studies the following factors were taken into account: (1) The native vegetation cover as an indicator of the aggregate soil conditions in the peat deposit; (2) the topography of the land in relation to the agricultural water table and its natural drainage; (3) the depth of the deposit, the morphology of its strata, and their degree of disintegration and impurities; (4) the na-

*Prepared for the Detroit meeting, September, 1915, and in the absence of Mr. Dachnowski, read by Prof. C. A. Davis.

ture of the mineral substratum and the probable geologic origin of certain salt constituents in the percolating water.

Heretofore the basis of relationship of peat and muck types has been some individual characteristic such as color, structure, texture, water-holding capacity, nature of vegetable material, etc., rather than the process by which these differences arise. This process is governed by the conditions imposed in the deposit and is superficially termed disintegration. But it cannot be too strongly emphasized that to a certain extent the factors or modifying agencies in the process can be controlled. Even a brief study of the natural vegetation successions leads one to the conclusion that the bacterial, chemical, physical, and mechanical forces working together in a peat deposit produce changes that on the whole augment the efficiency of the soil as a habitat for higher plants.

In texture the greater proportion of Ohio peat soils consists of fibrous and felty material derived from sedges and grasses. The woody components are the more resistant parts of trunks of trees, and of stems and branches in all stages of decay, rarely belonging to the resinous evergreens and conifers; the material comprises, roughly, 10 to 15 per cent of the whole mass in any deposit. The components that fill the interstices of the fibrous mass consist mostly of a structureless, granular or plastic, colloidal debris—particles of tissues from various sources—from the more labile short-lived mosses, ferns, and herbaceous and woody plants, and from the more resistant residue of leaves, rhizones, roots, spores, seeds, cells, and their contents. This groundmass varies in amount from 15 per cent in heath peat, containing much waxy and resinous material of great resistance to decay, to 60 per cent and more in peat from water plants, which is thought to contain a higher fat and protein content.

In the biochemical changes bacteria and fungi, and to some extent small animals (worms, insects, etc.) are undoubtedly the most effective. That these organisms in the soil can produce substances injurious as well as beneficial to higher plants need scarcely be elaborated here. Other agencies include the oxidizing and reducing power of roots of plants, the action of various enzymes, and the purely chemical changes that are constantly taking place. The lower strata of a peat deposit are generally saturated with water, and changes in texture and color appear to result from fermentation and gas formation caused in part by anaerobic bacteria in withdrawing oxygen from the peat constituents. The granulation and the darker color of the surface peat seem to be due largely to weathering —to drying, heating, and freezing, to oxidation, and to other physical and chemical reactions. The more resistant components of the peaty residue are particularly amenable to this weathering process.

There is no necessity for the difference of opinion and the

confusion existing in the use of the terms peat and muck. Agriculturally and physiographically the two represent markedly different classes or groups of peat soil, requiring different kinds of cultural treatment for successful utilization. Both represent accumulations of plant remains, derived frequently from the same plant associations, and both exist in different stages of decomposition of vegetation debris. The principal and the most important difference is in the topographic conditions that lead to the deposition of the large amounts of silt and clay found in muck. Areas overflowed by muddy water, those in which stream erosion and sedimentation are actively at work, shallow shores surrounding the deeper peat depositing basins of water, or shallow lakes agitated by waves invariably give rise to muck. The conditions of the process are quite distinct from those of peat formation on flat land surfaces under very moist atmospheric conditions, and those in depressions filled with water and characteristic of a relatively immature topography. Of course, no strict line of distinction separates the two in such area, either on the basis of salt content, color, texture, etc., where the physiographic process in its action gives rise to both conditions.

However, the interest in peat and muck soils to-day primarily concerns what they are producing and what they can be made to produce under scientific treatment. Hence to be useful to the practical farmer types of soil can not be of merely ecological, botanical, or biochemical interest. The distinctions in them, to have significance to the farmer, must be in terms indicating the character of growth, the composition of the stand and the yield of any specific crop that they will produce. Usually the areas of peat that are adapted to grazing are not suitable for some time to agricultural crops or to truck gardening; hence one is justified in not paying the high and constantly advancing prices now demanded for peat and muck soils.

The field observations of the writer indicate that a comparativiely thick "weathering crust," especially the nature and the amount of the peaty groundmass in it, is the most noticeable characteristic of a good peat soil; this constitutes a distinguishing feature of nearly every productive area examined. Upon the proportion of the groundmass to the fibrous and woody material depends, it seems, the probability of quickly establishing some satisfactory system of crop production.

Controllable Factors in Peat Agriculture.

Peat soils have been cultivated only for a short time. A large proportion of the Ohio peat soils has not reached a very advanced stage of productivity, and their capacity has not been fullv tested as yet. Individual farmers have reached a fair measure of success, but the results as a whole are reported not to have been entirely satisfactory, particularly in the western part of the State, which is underlaid by limestone. In the opinion

of the writer the poor returns in profit are due, in part at least, to a lack of familiarity with the methods of handling and with different field conditions and needs of the several types of peat and muck soil.

It is impossible to discuss the agricultural possibilities of any peat soil without considering some of the important controllable factors that influence the results obtained, factors for which the farmer is personally responsible and on which the permanent improvement of these soils largely depends.

Drainage.

The writer's observations have convinced him that little or no attempt has as yet been made at a system of applying water to the soil that is based on the physiological activities of crops. The assumption seems more or less popular with those engaged in peat agriculture that all plants require the same water table in the different peat and muck soils and the same amounts of water during their different growing periods. This is unquestionably wrong. The low productiveness of some of the less productive areas is decidely due to improper drainage. The general practice not only leads to positive injury to specific crops but is detrimental to the soil as well. The depth and width of tiling or of ditching should at present vary with the texture of the soil and its immediate subsoil; no other general advice can be given. It is highly desirable that a closer record be kept of the water table. The drainage system for the well-decayed, firmer soils is generally excellent, but that of the rawer, more fibrous soils has in most cases been carried out too rapidly and on too extensive a scale. As a consequence of the over-thorough and rapid drainage the looser, fibrous soil is disintegrating too slowly, does not form readily the necessary groundmass, does not shrink or settle, and even after repeated cultivation, remains fibrous and woody. It heats up rapidly, charrs, cracks, and at night cools off too easily. The crops in their characteristic root responses and top growth give every symptom of injury from drought. Even in the case of well decayed soils which on account of their finer, granular texture and greater absorbing surface have an increased retentive capacity for water and for fertilizer salts, the capillary movement rarely exceeds 4 feet above the water table. In instances such as these irrigation during periods of drought is as much needed as drainage. Dams and checkgates should be installed to raise the water table and to prevent the loss of crops during the critically dry seasons. A source of water supply such as this would be serviceable also against winter killing, early frosts, and, especially unfavorable distribution of rainfall, which is often more important than any cultural method in producing profitable crops. It is interesting to note that in only two instances did the writer observe a system of drainage combined with one of irrigation.

Underground Water Courses and Subsoil Drainage.

Underground water courses and subsoil drainage have been encountered on peat areas where flooding and surface changes were recently in operation. Such places are found mainly where sand is the underlying material. Consequently the peat and muck subsoils above these newly formed water courses dry out and crack. To an observer examining merely the surface soil this condition is not very conspicuous, but a closer study of the vertical cross section of the deposit and of the plants with their root system, healthy in general appearance but limited in downward growth and branching, reveal the unfavorable drainage conditions.

Waterpockets and deep basins as aberrant features of surface or of subsoil topography explain the low productivity of some peat and muck soils, especially in regions where the character of the subsoil and the natural drainage system lead to springs and artesian wells. The water accumulates in the peaty basins, keeps the soil very cold, and does not allow the degree of aeration advantageous to the growth of economic crops. The decay of the organic material is considerably retarded and modified, and the end products differ from those of the adjoining fertile tracts. Peat soil of that type has been found to be predominantly that formed from acquatic vegetation, being plastic and rich in decomposing nitrogenous material. Especially during prolonged dry periods the areas are easily recognized as they are favorable to luxuriant growth; in wet seasons, however, the soil conditions lead to an almost complete failure of the crop. Special methods of drainage, such as deeper open ditches, or deeper wide laterals, or penetration of the hard-pan by means of wells or holes, to a gravel-bearing layer, are the more feasable correctives.

In some portions of Ohio and the neighboring Lake States the subsoil topography favors water courses and springs that are fed from shale formations and rocks native of the region surrounding the area. They contain in solution considerable quantities of magnesium carbonate and salts of iron. When the water containing the salts in solution is carried to the surface by capillary movement and is exposed to the air, considerable deposits are formed of fine white, red, or brown sediments. It has been found that bacteria are active in the oxidation of the sulphur and iron compounds into sulphates, but the process of the transformation and the advantage from inoculating these soils with "sulphating" bacteria has not been studied to any extent. To a certain degree chemical oxidation in the soil may bring about the formation of sulphates. As oxidized efflorescences they are seldom injurious to the roots of plants unless present in excessive amounts, but in the form of an unaerated solution, the soil, they are known to be poisonous to plants, to limit favorable bacterial activity, and to cause much trouble in

the soil. The root habits of the plants vary and show marked reactions; the development of the roots is superficial and mostly confined to the upper 5 inches of soil, whereas those extending further down are short and brownish, and show a diseased condition. Where these difficulties arise within the soil, one practice of remedying them is a thorough breaking up of the soil and repeated tillage so as to expose the soil to the air. Often a ridging of the surface soil, frequent harrowing or deeper mulching during the growing season of the crop, has proven beneficial. If the drainage system includes checkgates and other provision for irrigation, frequent leaching of the soil should prove advantageous. A heavy application of lime at a point four to 6 inches below the soil surface is effective to render harmless the action of injurious compounds. An application of manure, or of clay, fine sand, or gravel improves the condition, but the latter method is only a temporary amelioration. It is commonly practiced in Ohio.

Tillage.

No satisfactory data are available as to the best methods of preparing the soil. Some farmers practice fall plowing, whereas others prefer spring plowing. Subsoiling does not appear to give better yields where it has been tested except after a long period. The practice of disking has not been tried sufficiently to warrant any definite recommendation at this time: it is thought to be the more profitable method of preparation for crops of small grain following corn or potatoes.

The majority of Ohio peat farms contain areas of soil relatively poor in its physical condition. Upon the brownish, fibrous types plowing should be deep. The soils require summer heating and drying and winter freezing before granulation and darkening will take place. The peat and muck soils consisting of woody material should be deeply plowed also, and left in the rough furrow slice during winter to allow the action of frost and air to promote granulation.

It is more profitable also to practice deep plowing in the case of shallow peat deposits underlaid by clay or heavy loam at a depth of 2 feet and less, as the water contact between peat and clay is poorer than in those underlaid by a sandy loam

Spring plowing should be resorted to mostly in the case of the well-drained and well-decayed, humified soils that are in need of conservation.

Proper cultivation of tillage is of the utmost importance as a remedial measure for all types of peat and muck soil, and is next in importance to drainage. Tillage is essential to a porous condition of the soil and maintains an effective weathering; it raises the soil temperature early in the season and thus prevents any possible injury from late frosts. As has been stated above, peat and muck soils often contain substances that are injurious

and even poisonous to higher plants. Exposure to air in some instances causes precipitates in a relatively insoluble form, whereas in other cases it oxidizes them to a considerable extent. Frequent cultivation aids in the free circulation of air and improves also the condition for the development of useful microorganisms.

Cultivation or tillage upon peat soils should be shallow for growing crops. The greater part of the roots of plants is well distributed in the plowed soil and any injury to them from improper cultivation or deep tilling results in a lower yield. A soil in good tilth and without weeds requires little or no cultivation.

Tillage is practised usually in the preparation of a seed bed, and during the growth of special truck crops to further the development of a branching and supporting root-system. It is of advantage also for the purpose of ridding the land of weeds, injurious insect larvae, and several of the plant forms causing diseases of roots. In every case the surface soil should be mulched and receive frequent level tillage. The looser peat soils should be packed by heavy rollers to produce a firmer structure for the movement of soil water. Furrowing and ridging of the soil should be practiced only upon areas where the water table is relatively too high.

Manuring the Soil.

The disintegration of the more resistant components of peat and muck soil can be hastened both by tillage and also by incorporating with it some fresh organic matter such as stable manure, grass-root sod, or clover and other legume crops. These disintegrate much more rapidly and thus contribute to the necessary groundmass of organic material as well as of inorganic constituents, and also stimulate the development of desirable soil bacteria. To obtain the greatest value from stable manure it should be applied to the soil after only short storage.

The beneficial action of stable manure turned under peat and muck soils has been reported by many farmers and has been noted in many experiments in the greenhouse. The benefit is especially marked on the newer peat soils. The reason advanced by some farmers and investigators for such beneficial action is said to be the ready solubility of potash from straw. In the opinion of the writer, however, the returns from such treatment are attributed to the bacterial inoculation which aids in continuing the decay of the resistant woody and fibrous material and in establishing a more normal balance of bacteria in the soil. Even a grade of poor, reddish peat, that in itself is an inactive and inefficient fertility constituents becomes valuable when propperly composted with fresh stable manure or used as stable litter. Bacterial action is hastened if a fair amount of lime is present

Liming the Soil.

The majority of peat and muck soils in Ohio are not sufficiently well weathered and granular. A number of them show signs of acidity. In a few cases such a condition is reported to be due to artificial fertilizers that have been used on the soils too heavily; in other instances it is caused not by the absorbing capacity of the soils but by the presence of sulphides contained in the shales of Ohio. The acidity is usually corrected by the application of lime. It should be stated, however, that acidity may arise in various other ways, and may persist only for short periods of time. Moreover, not all acid peat and muck soils are improved to a like degree by the addition of lime, nor do they need to be corrected in all cases, for, in the chemical reactions caused by it, acidity often aids in converting into available form the inert components and the silt or clay added.

Frequently it has been found beneficial to use ground limestone or slaked lime at the rate of 2 to 4 tons per acre. No injury is feared from heavy applications, especially with deep plowing. Smaller amounts are generally applied after plowing, when they are thoroughly harrowed into the soil. Whatever the nature of the lime used as a corrective, whether ground limestone, air-slaked or water-slaked lime, gypsum, marl, or crushed*-shell lime, in every case the material should be thoroughly worked into the soil, preferably at least 4 to 8 inches below the surface. The relative advantage of the several kinds of lime is not well understood.

Lime does not always increase the yield of certain crops, for example, corn and potatoes; and it does not appear to react readily with the soil in certain instances. It should be used, however, when a rotation of crops is contemplated. Autumn application of lime to peat soils is preferable and is essential to the growth of leguminous crops, such as alfalfa, clover, and, to a less extent, soy beans. The texture of the soil and its water-holding and water-conducting capacity are also improved. Lime improves indirectly as well as directly the physical properties of the soil promoting its decay and lessening its packing. However, conditions frequently arise under which the application of lime is seriously injurious to both soil and crops. As is well known, lime encourages the development not only of the nitrogen-gathering bacteria which live in the nodules on the roots of clover and other legumes, but also the nitrifying and the nitrogen-fixing bacteria in the soil, which have the power of accumulating nitrogen and rendering it available for the needs of crop plants. Peat soils high in available nitrogen* may show for a time luxuriant and vigorous growth. Under these conditions further applications of lime appear to be an additional stimulus to nitrification and cause rapid deterioration in the crop and severe injury from abnormal nutrition.

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*Bull. 16, Ohio Geolo. Survey, 1912, pp. 190, 382.

Fertilizer Treatment.

On account of the many factors involved, it is as a rule difficult to decide with any degree of certainty in what combinations or in what ratio to each other mineral fertilizers have produced the best results. Indeed, with the different types of peat and muck soil the fertilizer practice still rests on experiment rather than on a rule derived from the compilation of statistics or from laboratory experiments. The fertilizers are applied more with a view of controlling the growth of such crops as are liable to be killed by early frosts and weeds, or are in need of quality improvement (flavor, nutritive value, or ability to stand storage and shipping).

On the whole the application of the sulphate of potassium seems to have a preference in the western part of Ohio which is overlaid by limestone with a high content of magnesium carbonate, whereas the chloride of potassium is reported to be more effective in the eastern part of the State, known to contain abundant sulphur and iron salts in its underlying shales. In the light of practical experience among farmers who have used potash, it seems that crude salts of potash are suitable only for coarse, fibrous, and acid soils intended for pasture or meadow. Upon types of soil in a good state of tilth, potash, it is thought, improves the quality of the crop as well as the yield. The application of kainit is rather heavy for the first year (800 pounds per acre), but is used in much smaller amounts thereafter. It is preferably broadcasted and harrowed into the soil some time in advance of planting.

Phosphorus is usually supplied in considerably larger amounts than required to meet the needs of the crops to be planted. The first application is as high as 500 pounds per acre, but subsequently much less is applied. Phosphoric acid derived from readily available material such as acid phosphate or steamed bone meal is drilled or broadcasted at the rate of 100 to 400 pounds per acre. It is used in larger amounts for the higher priced truck crops.

In connection with the acid phosphate, lime is frequently employed after plowing. It is advisable to work the mineral constituents well into the subsurface soil. Other evidence seems to indicate that kainit and phosphate plowed under with stable manure, or clover and other green manures, are very profitable on fibrous soils. It is reported that fairly large applications give the advantage of accumulated residues of fertilizer salts to the crop of the second rotation.

Nitrogenous fertilizers are rarely used for general farm crops. For early planted truck crops, however, nitrate of soda, ammonium sulphate, or high-grade tankage is preferred. The fertilizer is applied as a top dressing in amounts not exceeding 1 to 2 per cent (50 to 75 pounds) in the mixed fertilizer. In some places the fertilizer is drilled after the plants have begun to grow.

Crops and Crop-rotation.

No one can state in advance what will prove to be the most suitable crop or the best crop rotation, partly on account of the different types of peat and muck soil, partly because of the fluctuating prices for produce.

In grain farming two years of corn is followed occasionally by potatoes, more frequently with specially bred strains of oats, barley, or millet the third year, and timothy with blue grass and some alsike clover the fourth year. Corn and also alfalfa have been grown for several years in succession, but should be rotated every five years. The coarser products should be returned to the soil. Where the corn crop is not too rank, cowpeas or soy beans are sometimes used as a cover crop. During the first rotation clover and alfalfa are not easily infected with nodule-forming bacteria, but even a partial stand affords great possibilities for the more fibrous peat soils.

In livestock farming, peat soils of the coarser, less productive, fibrous, and felty types are used with advantage. Timothy with an admixture of blue glass and some clover gives the best results, several years in succession, for pasture or meadow. The hay fodder is reported to be of the best quality. Mangels, carrots, turnips, and other root crops as succulent feed for stock in fall and winter use on the farm, and preceding grain crops as a rotation are said to give higher yields and to improve the soil.

Crop rotation in truck gardening is not practiced extensively at present. Such activity may be warranted from the commercial side as a means of livelihood, but it is not advantageous to permanent agricultural returns. The available data indicate that sooner or later both soil and crop suffer from injuries of various kinds, among which plant diseases and destructive insects and their larvae are in part the cause of heavy losses. Even some sort of rotation, for example, e. g. onion, followed by celery, tomato, lettuce, etc., may be considered as contributing to a beneficial system of peat-soil management.

Extension in Range and Quality of Suitable Crops.

Whether it is advisable for Ohio farmers of peat soils to raise extensively plants needed in the industries, such as hemp, flax, sugar beet, and peppermint, depends on many considerations, chief among which are those relating to our knowledge of their cultural needs, of the suitability of the locality to these crops and especially to the economic and competitive conditions. There is a recognized need for definite industrial crops of limited range. And just here the question arises as to whether co-operative work in crop extension and instruction in peat agriculture may be carried on as an experiment, when peat and muck types of soil and the place of specific crops in the general economic system of the country are so little known as yet and are so variable.

The agricultural development of suitable peat land should prove to be profitable. Among the natural by-products that perhaps could be advantageously raised until the soil is suitably prepared for cultivation, are the cranberry, blueberry, native fiber plants for rugs, carpets, and special grades of paper, and sphagnum mosses as packing material. There are other ways of utilization which have been mentioned briefly in another place. The use of peat for fuel, fertilizer filler and in stock food is gaining attention more and more. However, as these uses necessitate a special type of fibrous peat and call for considerable technical information, and as they involve the removal and complete destruction of the peat deposit, the utilization of peat for such purposes should be resorted to only in exceptional cases. In Ohio and in several other States the use of peat as a fertilizer filler is prohibited by law

In conclusion, this is to be said of the future agricultural possibilities of peat soils in Ohio and elsewhere: The indications are that they depend largely on more scientific and rational methods in the management of peat soils—in knowing how to prevent unnecessary troubles. In so far as peat lands are concerned, the essential objects are, aside from more effective organization, an increase in smaller farms, a greater use of fibrous soils for pasture, meadow, or general live-stock farming, and more intensive farming and greater specialization upon the better, suitable types of peat and muck. How far this is to be regarded as contributing also to the solution of the problem of cheaper foodstuffs for a country growing rapidly in numbers and in industrial wealth is a matter for inquiry by the economist.

DISCUSSION.

Mr. Wiedmer: I wish to point out that the use of peat as a fertilizer filler is not now prohibited in any of the States

Prof. Davis: I am not responsible for the paper. The objections that have in the past been raised by State officials against the use of peat as a filler, I have always attributed to the mistaken idea that peat has no value as a fertilizer.

B. Von Herff: Nitrogen is valuble as a market article if it is soluble and available for plant food. The nitrogen in peat is considered by chemists as being comparatively unavailable. The contention of officials is that the farmer purchasing a fertilizer is entitled to get full value in the form of soluble and readily available nitrogen.

Mr. Weidmer: The State laws were formerly as stated in Dr. Dachnowski's paper, but they now permit the use of peat when stated.

B. Von Herff: Peat is of value to the farmer from the nitrogen contained. It is an excellent material for fertilizer filler, because it improves the mechanical quality of the fertilizer.

Prof. Alway: It is my impression that many of the States

object to using peat to furnish part of the guaranteed nitrogen in a fertilizer.

Dr. Patten: It has yet to be shown by experiment that more than 25 to 30 per cent of the nitrogen in peat is available. Connecticut, Rhode Island, New Jersey, Vermont, Massachusetts, and I think other States require a statement on the package containing fertilizer that peat is used as a filler.

Mr. Kleinstueck: It seems to me we should have a special committee of this Society appointed to deal with the matter of legislation in the several States on this and other subjects relating to the use of peat and development of peat lands. We should not allow our work to be undone by unfavorable legislation based on mistaken ideas with regard to the value and uses of peat.

The Agricultural Utilization of Muck Lands

By C. S. Robinson *

Interest in the agricultural utilization of muck lands has increased enormously during the past decade. Largely on account of the campaign of education that has been carried on in Michigan, requests for information regarding this type of soil have increased over 500 per cent in the past five years. An inspection of the programs of the American Peat Society affords another indication of the increased attention being paid to this phase of the peat question. At the Kalamazoo meeting only about 20 per cent of the scheduled original papers were on agricultural subjects; at the Duluth meeting the number was doubled, and at the present meeting nearly 70 per cent of the program is devoted to the discussion of various agricultural methods for turning to profitable account this hitherto much neglected natural resource. These are only two of the many "signs of the times" that one may read in the greater attention manifested in every quarter, in the numerous articles in agricultural periodicals, in experiment station bulletins, and in the serious, systematic, scientific investigations being conducted in the various laboratories of the State experiment stations and the United States Department of Agriculture. Part of this must of course be attributed to the general increased interest in all agricultural subjects; part of it is perhaps due to the increased demand for farm lands of all sorts; but surely some of it must be credited to the greater appreciation of the many advantages that muck soils have over soils of other types.

Unfortunately, muck soils in their natural condition are generally unfit for use and considerable initial expense is required to clear and drain them. Partly on this account, partly because of ignorance of the best methods of reclamation, and partly because their value when properly developed is not realized, they are usually the last parts of a district to be utilized. So common is it to see the highland cultivated to the edges of a marsh possessed of far greater powers of production that the senses fail to record the astonishment we should feel at the neglect of these latent sources of so much wealth to our agricultural interests. Not only do they furnish no contribution themselves towards the income of their owners but they actually detract therefrom by increasing the expense of cultivating the surrounding upland.

The methods of agricultural utilization fall naturally into two groups, that in which it is used in position as a soil for growing crops, and that requiring its removal from the deposit

*Read at the Detroit meeting, September, 1915

for use as stable litter, fertilizer, etc. Economically, the former method is by far the better. Even though the initial expense is higher and the immediate profits less, deposits should, wherever possible, be used in this way. By this method the returns are made perpetual, and under proper treatment the value of a deposit may be steadily increased for several years after its reclamation. The ultimate returns are of necessity greater because extended over a longer time. This method of utilization cannot be too strongly recommended and in this age of conservation, while the movement to develop this natural resource is still in its infancy, let it be so directed that in years to come its progress will not be marked by milestones of worthless ponds rather than of fertile fields.

If the deposit is used as a basis for fertilizer it is sooner or later destroyed. The material serves a passing end but in doing so is ruined, furnishing a temporary source of profit which leaves behind it nothing but the place from whence it came—and that unfit for further use. Yet there are some deposits that from their very nature must be developed by this method, and for these of course it must be recommended as better than none at all.

Usually the first step in the development of a peat deposit for any purpose is drainage. If the deposit is to be used for crop production a permanent drainage system should be constructed, and in many cases it should be of such a type as to permit the regulating of the water table. If the peat bed is to be used for some purpose that requires its removal, a less expensive and complicated system will answer. It should always be borne in mind that the greater the amount of water that can be removed in the bed itself, the less will be the amount to be handled and removed later.

The second step is the clearing away of undecomposed vegetation. One of the most common methods of doing this, where timber is absent, is by burning. Yet in this process great caution should be used. It should be done only at a time when the bog itself is so wet that it will not burn. Too many times a layer of valuable peat or muck is completely destroyed, leaving only an ordinary soil, perhaps slightly enriched in mineral fertilizing ingredients from the ash of the burned material, but generally far less productive than before the burning.

Two of the most common inquiries regarding muck soils are "What kind of fertilizer shall be used?" and "Do they need lime?" In answer to the former it may be said that such soils usually respond to the application of phosphoric acid and potash. Nitrogen they, of course, already possess in abundance, though most of it is in a form unsuitable for plant use. Enough of it either is already available, or can be made so by an application of manure to render uneconomical the addition of commercial nitrogen. The liming these soils may or may not be advisable.

Usually an ordinary soil which shows an acid reaction to litmus demands the application of lime. A good many muck soils will give a positive test for acidity with litmus paper yet they do not behave as do other acid soils. It has been stated that the ordinary tillage methods frequently overcome acidity in muck without any further treatment being necessary. Even when such is not the case the acid does not always decrease the fertility of the soil. Clover for instance will sometimes attain a remarkably luxuriant growth on extremely acid muck soils. European experience has shown that excessive liming of much soils is to be avoided as such practice produces harmful effects.

The use of manure on muck soils is to be highly recommended. As was mentioned above, these soils contain large quantities of nitrogen most of which is, however, in the form of chemical compounds unfit for plant use. The application of manure aids in the process of rendering these available. In the application of manure, it is not the added organic matter alone that produces the results but it is the fact that the decaying manure can set up a decay in the muck which is more important than the mere addition of a small quantity of fertilizing material. In experiments conducted at the Michigan experiment station nitrification was much greater in mixtures of peat and manure than in either one alone.

Almost any crop can be grown on muck, and furthermore can be grown with greater profit than on ordinary soils. Celery, onions, carrots, lettuce, cabbage, horseradish, and peppermint are special crops that do exceptionally well on such soils, but the same statement holds for ordinary farm crops, especially corn and hay.

Among the other agricultural purposes to which peat may be put are the following: As a stable litter, as a fertilizer, either directly or after treatment of one kind or another, as a stock food, and as a packing material. Its value as a stable litter, especially in dairy barns, can hardly be over estimated. Not only is it an exceedingly efficient absorbent for liquids but it is also a powerful deodorizer and greatly diminishes the objectionable odors of the barn. Owing to this same property it can absorb large quantities of gaseous ammonia formed from the decay of manure which would otherwise escape into the air and be lost. The following table shows the relative absorptive powers of various materials used as stable litter.

Relative Absorptive Powers of Various Materials Used as Stable Litter.

Sample No.	Material	Pounds water absorbed by 100 pounds material	Quantity water absorbed by other materials compared to quantity absorbed by straw
1	Excelsior	283.9	0.76
2	Shavings	288.4	0.77
3	Straw	374.3	1.00
4	Muck, black	381.8	1.02
5	Muck, black	387.3	1.03
6	Marsh hay	417.2	1.11
7	Muck, brown	558.7	1.49
8	Sawdust	750.9	2.01
9	Peat, brown	850.8	2.27
10	Peat, brown	1625.3	4.34

In addition to these advantages, muck or peat will also add materially to the value of the manure on account of the nitrogen which it contains and which will to a large extent become available after mixture with manure. Because of the action of the manure on the peat, it can be used in much greater proportion than can other litter without reducing the quality of the mixtures.

One set of experiments made with a sample of muck from the northwestern part of Michigan indicated that the same increase in productivity could be obtained with a mixture of three parts of muck and one of manure as with manure alone. In districts where manure is scarce and there is plenty of muck this use of peat would be an easy way to improve soil fertility. The value of such a mixture could be still further increased by the addition of certain mineral fertilizer. The following are the comparative yields of corn obtained in pot experiments at the Michigan experiment station in which a mixture of peat and manure was used as a fertilizer in conjunction with the mineral fertilizer indicated:

Comparative Yields of Corn in Pots Containing Mixtures of Peat and Manure and Mineral Fertilizer Indicated:

Mineral fertilizer added.	Corn yield, per cent.
None	100.0
Lime	113.2
Gypsum	120.1
Acid phosphate	126.3

The direct application of untreated muck alone to mineral soils, unless in sufficient quantities to materially change the condition of the soil, cannot be said to be entirely successful. If it can be applied in quantities large enough to form a significant proportion of the mixture, then it may so change the physical condition of certain types of soil as to produce a marked benefit. This statement does not of course apply to muck that has been

subjected to such treatment as roasting or acidifying by which the nitrogen may be rendered to a large degree available for plant use.

The development of peat for other purposes, namely as stock food, fertilizer filler, and packing material, is assuming considerable prominence commercially. Such enterprises contain great possibilities for the utilization of many deposits that would otherwise be of no value.

Discussion of Dr. Robinson's Paper.

Prof. C. A. Davis: Dr. Robinson's paper is of great interest, not only to the members of the Society, but to a large number of persons throughout the country. Our peat and muck soils are the most abused and most neglected, and yet are the most valuable type of soils. They are easily worked, and where the proper treatment and cultivation are applied the yields are both certain and great.

Baron Von Herff: In some cases it has been the experience that clover would not grow on muck land; and this is said to be due to sourness of the soil.

Mr. Robinson: Acidity of the soil prevents bacterial growth rather than plant growth. In a case that came under my notice at Vassar, Mich., a man who was trying to raise crops on a positive muck soil had failed in raising anything. The soil on examination proved to be very acid, but after manuring clover grew luxuriantly.

Prof. F. J. Alway: The popular idea as to the effect of soil acidity does not always hold good. Sometimes clover will grow luxuriantly on acid soils. In some cases it will grow well on bogs, and in others not. Greenhouse tests are desirable to determine the character of particular bog soils. In some experiments carried out recently in Minnesota clover failed altogether on a particular piece of bog land. On the same soil in the greenhouse it was a success. The greenhouse plat, however, was watered with tap water which contained lime, and this may have accounted for the difference.

Prof. Davis: I have frequently noticed that wherever a roadway crosses a bog, clover appears, and often grows luxuriantly. I have seen it thus selfseeded on the Alfred bog in Ontario, and on a number of Michigan bogs. Experience proves that peat does not support legumes of certain kinds, when it is in the raw state, and it may be said that the conditions of their successful growth on such soils are not yet well known.

Mr. Ranson: Would Prof. Davis lay down as a principle that the nitrifying process cannot go on if there is acidity of the soil? In my own experience I don't seem to get any bacterial action until the soil is sweetened?

Prof. Davis: Our knowledge of the subject is not definite enough to permit the laying down of a general rule. Not all

peats are acid. I would like to ask Mr. Robinson as to the depths of the bogs used for agriculture in his work.

Mr. Robinson: Depths vary all the way from a few inches to unknown depths.

Mr. Moore: Our Ontario bogs can in many cases be effectively drained at moderate cost. The Alfred bog, on which I have been working, has excellent drainage facilites to the Ottawa River, which is only a few miles away. By leaving part of the peat on the bog when excavating for fuel manufacture, the surface will eventually become excellent farm land.

Mr. Kleinstueck: That is the practice in Holland and elsewhere in Europe.

The Use of Peat in Commercial Fertilizer

By H. E. Wildeman, of St. Louis, Mo.

Many users of fertilizer and a large part of the general public think that all commercial fertilizers contain a large per centage of material that has no plant-food value and has been added solely to make weight and bulk. They think that everything in a bag of fertilizer that is neither nitrogen, phosphoric acid, nor potash consists of this inert material commonly called "filler," and the consumer must therefore pay for a lot of worthless material to get a few pounds of food for his crops.

As a matter of fact, this so-called filler is present because it has been put there by nature and is a necessary part of the chemical compounds that contain the essential plant-food elements.

Should we want to apply 100 pounds of nitrogen to a certain amount of land we cannot apply pure nitrogen for it is a gas and can neither be applied to the soil nor used as a food by the plants.

Consequently nature (and now man) combines this gaseous nitrogen with various other elements and gives us chemical compounds in a solid form which we can use and the plants can assimilate.

If we consider Chili saltpeter, or sodium nitrate, we find that only a little over 16 per cent is nitrogen and that in order to get 100 pounds applied to the soil it will be necessary to add somewhat more than 607 pounds of the solid sodium nitrate. Would it be correct to call the 507 pounds of inert material a "make-weight" filler?

Phosphoric acid would absolutely destroy plant life if applied to the soil undiluted and we use it as prepared by nature in combination with other elements, in the form of bone or rock phosphate.

Potassium is a metal which will float on water, and when brought into contact with water bursts into flame with a violent explosion. Surely we cannot use this to feed plants! Nature has again provided us with compounds containing this valuable element in an easily manipulated form, such as potassium chloride and potassium sulphate, which contain inert substances together with the potassium.

In a ton of 3-9-3 fertilizer there are 300 pounds of plant food, yet the 1,700 pounds of salts, organic matter, etc., that are present are needed to contain these 300 pounds of essential material. And unless the so-called inert material were present the concen-

*Read at the Detroit meeting, September, 1915.

tration of the essential elements would destroy all forms of plant life. Although the presence of the inert material is necessary, no manufacturer is going to use too much of it and therefore not give the consumer the value of his purchase price, for all sales, as you know, are based on the actual amount of plant food present as determined by analysis, and it would be suicidal for a fertilizer mixer to add so much filler that the mix becomes of no value as a fertilizer.

I think, therefore, that we are safe in assuming that a dilutent, filler, or carrier, or whatever term you want to apply to it, is necessary in a complete commercial fertilizer. The question now arises as to what is the most suitable substance to use for this purpose.

Numerous substances have been used, most of which have had no value as a plant food and some of which have contained material that has a deleterious effect on the growth of plants. We will not dwell on the various fillers at this time, but will consider for a moment one material that has been found eminently satisfactory for this purpose, namely, peat.

The use of powdered peat as a filler permits the use of substances in commercial fertilizers that could not be used otherwise. There are many kinds of waste matter from the meat packing plants that could not be used in a fertilizer unless in conjunction with peat, because they are hygroscopic and absorb moisture from the air, and either cake into hard masses, or give off offensive odors, thus indicating decay. When animal matter decays its nitrogenous matter, which makes it of value as a fertilizer, passes into the air as gas and thus is lost. Peat not only prevents such decomposition to a large extent, but acts as an absorbent when decomposition does occur and retains the valuable gases, which thus pass from the animal matter into the peat and are still available for plant food when the fertilizer is applied to the soil.

The concentrated tankage or so-called "stick" that is prepared in meat-packing establishments by evaporating the water from the tanks in which the tallow and grease is cooked, has, as you know, been used for many years to increase the nitrogen content of fertilizers. This material is a dry, solid powder when first prepared but it is extremely hygroscopic and soon absorbs moisture from the air, becoming very sticky and finally coalescing into one solid mass the size of which depends only on the size of the pile of "stick." After a time it was found that by adding a small amount of copperas to the water before it was evaporated this action could be overcome to some extent. Recently, however, stick has been found to be a valuable material in tankage used for stock food. Copperas would be injurious if used in a food to the extent that it is used in "stick," so it became necessary to find a suitable substitute. This has been found in peat. In fact, peat is an improvement, for "stick" made with the ad-

mixture of peat remains in much better mechanical condition than when copperas is used.

The improved method of producing concentrated tankage consists in evaporating the tank water to a suitable consistency in vacuum pans, adding about 40 per cent peat, and then mixing the wet peat with the regular tankage just before it enters the driers. This gives a uniform product of excellent mechanical condition and rich in ammonia. If the material is to be used in stock food it will contain nothing injurious.

Many of our larger cities are utilizing the garbage for the production of grease and tankage. Garbage tankage is a very low grade of fertilizer material, not only on account of low ammonia content, but also on account of its peculiar mechanical condition. It is so very light and fluffy that it is with difficulty incorporated in a complete fertilizer. Experience has shown that if peat is added to the garbage tankage as it enters the driers a greatly improved product is obtained as regards its mechanical condition, and the ease with which it may be mixed with the other material. It is also found that the presence of peat in the tankage as it goes through the driers overcomes to a large extent the burning of particles of the material in the driers and eliminates the resultant bad odor arising therefrom, which has been the cause of much complaint, and many lawsuits wherever garbage has been reduced.

It has been found that the use of peat in the preparation of fertilizer from fish is of advantage in that the peat improves the physical condition of the scrap, prevents the disagreeable odor, and reduces the danger of fire. Fish scrap contains a considerable amount of oil, and many fires are produced in the storehouses on account of the oxidizing and heating action of this oil in contact with the organic matter of the fish scrap. When peat is added this oil is largely absorbed into the peat and retained in such a manner that the chances of fire from spontaneous combustion are materially reduced. This absorbing action also accounts for the retention and elimination of much of the "fishy" odor always associated with fish fertilizers. The improved physical condition results from the dry pulverulent nature of the peat. Fish scrap that has peat mixed with it will adapt itself to mechanical mixing with other fertilizer materials much more satisfactoryrily than will scrap that contains no peat.

By far the most extensive use of peat as a filler is in the manufacture of finished commercial fertilizers. Its advantages in this connection are numberless.

Acid phosphate of acidulated rock has a marked tendency to cake and is handled with extreme difficulty. This disagreeable feature is augmented when the material is used "green" or before it has had an opportunity of becoming thoroughly dry before use, a condition that often arises in a busy fertilizer plant.

When the caking action has taken place the material will not flow from the bagging machine, neither can it be used in a drill

when applied to the soil. This is overcome by the use of peat.

Even if the acidulated rock is "green" the addition of peat will overcome any tendency to cake; the fertilizer may be bagged without any inconvenience and may be easily drilled; this improvement is due to the physical nature of the peat and to other factors previously mentioned.

Agriculturists, after having used a fertilizer that meets their requirements, desire naturally the same grade of material in future shipments. Among other properties they note the color of the product and many of them insist on the same color from year to year, thinking of course that the same grade of fertilizer should always be of the same color. Although we know that the efficiency of a plant food is not influenced by its color, it is nevertheless good policy to produce material of uniform appearance. Manufacturers who have used peat in their finished product find that this otherwise difficult problem of uniform color is easily solved. The peat being of a black shade neutralizes any color that may be due to other materials present, and the fertilizer as sold has always the same appearance. This, of course, is of minor importance but it is worth bearing in mind.

In the above discussion we have dwelt on the use of peat in fertilizer material as a filler. We now come to the consideration of the more important and valuable property of peat, namely, its value as a plant food.

Over this subject many long, and I may say bitter, controversies have raged. The objections and opposition were no doubt sincerely advocated but were based on inconclusive evidence, ignorance, or prejudice, and I am glad to say that fertilizer authorities have now been convinced that peat, when properly prepared, has actual plant food value and that its use as a fertilizer is not fraudulent. Ten or twelve years ago no State that had fertilizer control would allow it to be used in commercial fertilizers registered in that State. By analyses, experiments, and actual proof, these officials have gradually been convinced that the material has value and at the present time there is no State in the Union that prohibits the use of peat as a fertilizer. As some one has aptly said, it is "just a question of convincement."

In the latter part of the year 1906 this discussion of admitting peat fertilizer was being carried on by many manufacturers and State officials A letter that came to my attention from a State chemist to a peat manufacturer contained the following sentence in conclusion: "Still I am free to say to you that I cannot see any way by which this material of yours can be allowed to be put on sale in this market."

Another letter from a State chemist a year earlier contained the following, which I want to quote at this time to indicate to you the marked reversal of opinion on this subject when the truth was developed. The letter was written before officials were familiar with the action of peat: "Your representative stated that it was used largely as a filler and was therefore of

great benefit to the farming interest and was certainly far superior to cinder and other worthless material used as filler in fertilizers. I replied to him as I do to you, that when we analyze a fertilizer containing nitrogen we get all the nitrogen out of it, and calculating the commercial value of the fertilizer, we do so at the rate assigned to the best grade of nitrogen such as that from cottonseed meal or blood. Consequently if a part of the nitrogen in a mixed fertilizer has been derived from peat, it will have too high a value assigned to it, and the farmer who buys it will be defrauded, as he buys the goods with the idea that all plant food he pays for is immediately available. If it did not contain any nitrogen at all, then its use might be allowed as a filler in common with other worthless filler materials. If the manufacturer could be expected to state when he registers his fertilizer that such a per cent of nitrogen in his fertilizer is worthless, that might alter conditions, but we have not yet arrived at this point and do not expect the manufacturers to make any such comment. I therefore consider the use of dried muck as a filler in fertilizers as a most insidious form of adulteration, simply because in the routine analyses of the laboratory all of the worthless nitrogen put in there as muck is calculated as though it were of the best grade and that value assigned to it in our printed bulletin. I expect to keep a sharp lookout for this material this year and we will certainly publish any fertilizer firms mixing it in their goods and exclude their goods from sale in this State."

The author of this letter had not done any work on peat at the time the letter was written, and he referred, in the letter, to some work that had been done by an investigator some years before. The results of this investigation have since been proven erroneous for commercial peat as we now know it. He (the author of the letter), has since, however, conducted a series of experiments himself and has studied the work of other recent investigators and now not only allows the use of peat as a filler in fertilizers, but as a fertilizer itself, and gives credit in his bulletins for all the nitrogen contained in the peat. I may say also that he is now one of the most enthusiastic advocates of the use of peat as a plant food.

One of the most important series of experiments carried out with the view of determining the suitability of peat as a fertilizer was conducted by the agricultural department of the State of North Carolina. In one series of tests peat was used as the source of the nitrogen and in the other dried blood was the only nitrogen-carrying ingredient. The two crops corn and cotton were used for the test, with the following results:

Plat No. 1 was unfertilized and was used as a control. The yield was 670 pounds of seed cotton.

Plat No. 2 was treated with:

200 lbs. acid phosphate,
50 lbs. manure salts,
350 lbs. peat (containing 9.52 lbs. nitrogen)

Yield was 1,025 pounds of seed cotton.

Plat No. 3 was treated with:

200 lbs. acid phosphate,
50 lbs. manure salts,
71.1 lbs. dried blood (containing 9.95 lbs. nitrogen).

Yield was 980 lbs. of seed cotton.

This indicates that the peat, with .43 pound less nitrogen than contained in the dried blood, produced 45 pounds more seed cotton. The plat containing peat produced a gain over the untreated plat of a little over 37 pounds of cotton per pound of nitrogen, whereas the plat containing dried blood produced a gain of only a little more than 31 pounds per pound of nitrogen.

Plat No. 4 was also unfertilized and was used as a control in the tests with corn. The yield on this plat was 11.6 bushels of shelled corn.

Plat No. 5 was treated with:

150 lbs. acid phosphate,
35 lbs. manure salts,
150 lbs. peat (containing 4.8 lbs. nitrogen).

Yield was 22.5 bushels of shelled corn.

Plat No. 6 was treated with:

150 lbs. acid phosphate,
35 lbs. manure salts,
64 lbs. dried blood (containing 8.96 lbs. of nitrogen).

Yield was 27.6 bushels of shelled corn.

The peat, that contained 4.16 pounds less nitrogen than the nitrogen contained in the blood, produced only 5.1 bushels less corn. The peat produced a gain over the untreated plat of 2.3 bushels of corn per pound of nitrogen, whereas the dried blood showed a gain of only 1.8 bushels per pound of nitrogen.

These results, which are so favorable to peat, must be considered as authentic for they were obtained by very careful work on the part of a State experiment station and are absolutely without bias. When these figures, together with others of equal authenticity, were presented to the various State officials they all (even those who were at first skeptical), acknowledged the plant-food value of the nitrogen content of peat and allowed the material to be sold as a fertilizer in their States.

One official, on receiving a copy of this report, said: "As you have submitted to us satisfactory evidence of the availability of the nitrogen in your special make of muck or dried peat, we herewith withdraw the embargo laid on it some years since and grant you permission to sell the same within the limits of this State."

Dried blood has always been considered the best form in which to apply nitrogen to the soil for plant food and we can hardly expect the remarkable results obtained in the tests just described to be due to the increased efficiency of the nitrogen of the peat over that contained in the blood, and we must look elsewhere for an explanation, that is, to the humus content or organic

matter of the peat, and the bacterial action, in conjunction with the nitrogen content.

It is well known that the nutrition of a plant depends not only on the supply of mineral food elements, but also on the presence of certain accessory organic food substances, very small amounts of which are sufficient to satisfy the needs of the plants. This subject is now being investigated in England, and among other materials the English investigators are studying the action of the humus of peat in connection with this property or supplying organic food substances. We may expect valuable information from this source later.

At your last meeting, in Duluth, Minn., Mr. H. C. Thompson presented a paper on the use of peat in growing greenhouse crops, in which he described experiments made under the supervision of the Government, that led him to the conclusion that peat is a very satisfactory and valuable material for that purpose. He said, "The indications are that a good type of muck soil can be used as a substitute for a part or all of the manure with very satisfactory results." He also said that uncultivated or raw muck soil gave much lower yields than the cultivated peat soil. This has also been found to be true in Illinois.

Part of a deposit of peat near Manito, Ill., has been in continuous cultivation since 1885, and peat from that part of the deposit is richer in plant food and gives better yields when used as a fertilizer than similar peat that has never been under cultivation. This difference in value is no doubt due to the improved physical condition of the soil and to the presence of beneficial bacteria.

It is the practice, therefore, at this plant to keep all of the soil under cultivation except that part from which the peat is being removed. After a particular field has been worked over and all the readily available valuable material has been removed, the soil is again put under cultivation and after a number of years, by proper manipulation, the surface again consists of marketable peat, well decomposed and with a 4 per cent nitrogen content on a dry basis. This indicates that the cultivation of peat land enriches its value as a plant food.

The deposit of peat to which I have referred is seemingly heavily impregnated with bacterial forms of life, some of them being in such numbers that a visible effect is seen in the form of a white mould, and some of which may have, to a limited extent, the power of fixing atmospheric nitrogen. Several years ago a fire destroyed one of the storage houses at this plant, and for two years the peat that was in storage at the time of the fire was allowed to remain in the open, unprotected from the weather. This material had been carefully analyzed daily as it was stored, and at the end of two years' exposure, when it was sold, an analysis was again made of each carload. During the two-year period there had been a gain in the nitrogen content equivalent to .3 per cent ammonia. This occurrence conclusively refutes the state-

ment sometimes made that peat loses in value when exposed to the weather, and it also indicates the possibility of a nitrifying action on the part of the peat bacteria.

Many manufacturers, and some users, of commercial fertilizers have been skeptical as to the value of peat on account of the fact that by the ordinary and well-known methods of determining the availability of the nitrogen in organic material, only one-third to one-half of the nitrogen in peat is shown to be available. This is a false position to take for these methods are only empirical and the actual nature of the complicated compounds in which nitrogen exists in peat is unknown or only surmised. The only correct means of determining this availability consists in making actual growing tests and studying the yields obtained. When this is done with properly prepared peat the results are out of all proportion to what might be expected from a study of the chemical analysis for availability, and until these compounds and their action on plants are known, and until the action of the compounds formed by them during their decomposition in the soil has been determined, the question of the availability of peat as a plant food cannot be completely understood. It is a fact that until recently practically every experimenter with peat as a fertilizer began his work with the notion that peat would never take the place of other nitrogen-bearing compounds, the idea being based on the results of chemical analyses which always showed a low percentage of available nitrogen. As he began to compare his yields from the plats treated with peat with the yields from the plats treated with the old "stand-bys," his eyes were opened.

This work has been steadily going on and the use of peat is constantly increasing, until now many fertilizer manufacturers use it as the only source of nitrogen in many of their brands of fertilizers.

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EDITORIAL NOTES.

The Detroit Meeting. The meeting of the American Peat Society, held at Detroit, Mich., in September, was a marked success in most ways. There was one weak feature, however, namely, attendance of the members. The meetings were not as well patronized by the membership as the value and variety of the papers on the program merited, as the attractiveness of the city in which the convention was held warranted, or as the hospitable preparations made by the local committee of arrangements deserved. The meetings were well attended but many of the old-time members were missed, both from the serious discussions which took place and even more from those less formal occasions where business matters were forgotten and peaters enjoyed themselves socially.

This meeting, the ninth in the history of the Society, as has been the case in the past, differed from all of those which have preceded it, and in the opinion of the writer, in at least one respect, surpassed all others. Unquestionably, the dominant theme of the meeting was the value of peat and peat lands in agriculture. This theme was discussed from many points of view by men who have studied it practically and theoretically and many valuable and suggestive points were brought before the meetings. Among those who were present, bringing with them detailed reports of important original researches into the fundamentals of the agriculture of peat and peat soils, were representatives of three State Agricultural Experiment Stations, who presented papers covering the details of the work they have in progress. Two papers by representatives of the United States Department of Agriculture and several by practical and successful farmers of peat lands were of great interest and practical value, since they presented facts and figures that showed how productive farms can be developed

from wild and undrained swamps and marshes. Some of the papers told of the crops that can be raised on peat lands and gave detailed methods of working them from the time the ground was plowed in the Spring till the harvest was gathered in the Fall.

Among other essentials, the fact was clearly brought out by the papers on farming peat soils that the man who expects to make a success of a venture into this field must avail himself of the experience of others and every reliable source of information, first regarding the soil itself and then drainage, the best kind of crops, methods of fertilizing, cultivating, harvesting, storing or marketing them, etc. In other words, the agriculture of peat soils is a highly specialized business and must be treated as such if the best financial results are to be attained.

Although peat agriculture was the chief subject of the discussions of the meeting, the production and uses of peat as fuel were by no means neglected. Very interesting and important papers on these subjects were presented, showing that some of the dreams of the earlier meetings of the Society, in respect to the economic production of peat fuel, were now fully realized for plants of the types described in the papers on these phases of peat utilization. Machinery for ditching and other agricultural operations received some attention and was the subject of one important paper.

A relatively new and very promising use of peat, namely, as an ingredient of sweetened stock foods, was presented and made the subject for discussion. The uses to which peat has been put in the artificial fertilizer industry and the changed attitude of the State fertilizer inspectors towards its use for this purpose, was brought up and considered.

Not the least interesting experiences of the convention were the ride through the city and the visit to a new addition to the city just being opened up, where the opportunity to see the practical operation of the Buckeye traction ditcher was given the Society. The ease with which this powerful machine cut deep trenches through the hard clay soil was very impressive. The social entertainments provided for by the local committee of arrangements left nothing to be desired in this line. No one who attended the Detroit convention went home sorry that he had been present.

Agricultural Research on Peat or Muck in the United States.

The muck lands of the United States in the aggregate cover many thousands of square miles and when properly drained and cleared, constitute the most productive and highest priced farming lands of the country. In their natural condition, on the other hand, as swamps and marshes, they are held as of no agricultural value and are often sold at very low prices. In most of the States north of the Ohio River and east of the Mississippi, there are few farms that do not have some muck land and in a majority of cases such land is still unused by its owners, largely because no definite

knowledge has been available as to how this class of land should be treated.

Within the past few years, however, the success attained by those who have used properly subdued muck land for the production of peppermint, onions, celery and other truck crops has awakened interest in the whole question of making the most of such lands and we have now a considerable number of reports of carefully conducted experimental work by trained agricultural experiment station workers and a considerable number of investigations still in progress.

Besides the work in progress in the several States, notably in Michigan, Wisconsin, Minnesota, Indiana, Ohio, New York, and in some of the New England States, the Bureau of Plant Industry of the United States Department of Agriculture has been conducting a series of important field and greenhouse experiments to determine the value of peat as a soil and as a fertilizer in growing certain commercial flowering plant and winter vegetable crops under glass. The work in the field is largely to test the value of traditional or "rule of thumb" methods of fertilizing truck crops and, if possible, to find by experiment what such crops really require to give the best returns with the least expenditure for fertilizers. This work is being done in co-operation with this Society, and one valuable paper of great interest to commercial greenhouse men and horticulturalists has already been published in this Journal. The Bureau of Plant Industry has also recently undertaken to determine the causes of the barrenness of certain areas of peat soil. The same Bureau has important investigations on cranberry and blueberry culture in progress. It is quite possible that other research work on the agriculture and horticulture of muck and muck soils will be undertaken by the State agricultural experiment stations and by the United States Department of Agriculture as the great need of such work becomes more clearly apparent. Two important series of investigations are now in progress at State experiment stations, which are being paid for in large part out of funds furnished by individuals, who have provided the money necessary to carry on the work because there were no State funds available.

The pioneer work so well begun will doubtless be expanded at many of the agricultural experiment stations, especially in those States where large swamps are being drained and reclaimed, and before long we shall have in the United States studies on peat and muck lands that will compare favorably with those which have been so successfully carried on in Sweden, Germany and other countries of Northern Europe. It seems evident that this work is important enough in its aspects to merit the earnest attention of National and State argricultural investigators.

The Work of Prof. Bottomley. For a number of years now Prof. W. B. Bottomley, of King's College, London, Eng., has been studying soil bacteria and developing a new method of en-

riching the soil by means of the application of cultures of certain bacteria which, by special and original methods, are made to grow abundantly in peat. The general methods of preparing the peat and of growing the proper bacteria have already been described at some length in this Journal (Jour. Am. Peat Soc., Vol. 7 [1914], p. 69), and papers published and lectures delivered since that time have apparently confirmed the earlier reports made by Dr. Bottomley before various scientific societies. In spite of this, however, and the enthusiastic commendation with which the lectures and demonstrations of Dr. Bottomley have been received by the leading English botanical societies, the British Board of Agriculture have refused to take any interest in the matter, either to investigate the method or to take charge of experimental work, apparently on the ground that nothing had been proved on a commercial scale. In October, 1915, however, the Royal Botanic Society, learning that peat lands with suitable buildings had been offered free for conducting large scale experiments, and that funds for carrying on the work had been provided in part by Mr. Robert Mond, while Dr. Bottomley was ready to give the necessary cultures of bacteria, voted to form a national committee to take charge of the experimental farm and thoroughly investigate the bacterized peat. Dr. Bottomley has refused to sell his process, although offered large sums of money by well financed private corporations and foreign countries. It is estimated that under present conditions the cost of properly treating peat by this method is about $12.50 a long ton, but yields of from 26 to 46 per cent more of various vegetables were obtained from land fertilized with one ton of bacterized peat than on adjacent areas of soil of the same sort yielded, although this was fertilized with 80 tons of barnyard manure.

It is hoped that this interesting process will be investigated in this country and detailed reports made on its value and applicability to our conditions. We should be able to get the best investigators in the country interested in such an important matter and have its true value authoritatively reported to us.

Abstracts, Patents, Etc.

Dr. Herbert Philipp, Perth Amboy, N. J.

LIMING PEAT SOIL.

(Th. Arnd. Landw. Jahrb., vol. 47, p. 371.)

The purpose of this investigation was to determine whether there was a relation between the liming and nitrogen decomposition of a detrimental nature in peat soil, and whether this was due to too much lime. The question also arose as to whether too much liming of peat would adversely affect the biological reactions. In no case could the lack of soil activity be noticed by the addition of lime fertilizer.

The results obtained with various peat soils regarding the reduction of nitrates to nitrites can be classified as follows: Neither in raw unlimed peat nor in limed peat soil was a decomposition of nitrate due to chemical action shown. Heavily limed peat soils innoculated with nitrate solutions showed no chemical reaction decomposing the nitrates. The formation of nitrites from nitrates in peat soils is dependent on the temperature; small differences in temperature influence the nitrate reduction, and this is further proof of the biological character of the nitrate reduction in limed peat soil. The formation of micro-biologically formed nitrites in heavily limed peat increased with increase of decomposition of the peat, so that the more decomposed the peat the greater the activity of the formation of nitrites. Liming that does not reduce the acidity of the peat soils does not enhance the nitrate reduction; only such liming as neutralizes the acidity of the peat or makes it alkaline creates the condition for nitrite formation. Only in acid peat soils are the nitrites quickly chemically decomposed. In limed peat soils in which the acidity is neutralized, chemical decomposition of the nitrites does not take place; the decomposition is conditioned by micro-organisms.

Thus, the first phase of the nitrate decomposition in peat soils covers the conversion of nitrates to nitrites by micro-biological activity. The chemical reaction between acid peat soils and nitrites resolves itself in the total decomposition of the nitrites. A part of the nitrite nitrogen is lost in the soil; the rest forms ammonia or amide compounds, partly as organically combined nitrogen.

Denitrification tests pointed to the following conclusions: On account of unfavorable climate conditions in acid peat soils in high situations, microbic decomposition of nitrates does not take place. In neutralized peat soils, however, a lively decomposition of the nitrate occurs. The nitrogen losses are dependent on the degree of liming. The results obtained allow the statement that

the harmful effect of lime on peat soil creates microbic nitrogen disturbances. In raw peat the micro-organisms have not the right conditions for their activities, while limed soils produce the right conditions. The liming of a nitrogen-bearing peat soil to which no nitrogen fertilizer has been added creates a condition in which the soil loses its nitrogen; the crop yields will therefore become less. By liming a nitrate-fertilized peat soil a part of the nitrogen is reduced to nitrite, another part is lost by denitrification, with the result that subsequent crops have poor yields.

Meeting of the German Peat Society, Berlin, Feb. 24, 1915.

Chairman Von Wagenheim stated that the importance of the German Peat Society had become recognized by the state officials and the people since the Emperor, who is much interested in agriculture, became a member.

A report by Dr. Alves, the secretary, stated that there were signs of progress in all peat sections during 1914. Even if at the outbreak of the war there was a slight intermission, the peat under cultivation was soon again being worked with double energy. No doubt the state regulation had helped this considerably. Of especial value were the prisoners of war, as was also the large area of undeveloped peat deposits available for agricultural purposes

Assistance was received from many sources; for instance, the Government contributed 25,000 marks. Further, from the potash fund, the Government appropriated 84,000 marks, with the understanding that potash was to be used in the cultivation of the peat soil. From the Prussian department of agriculture the society received 8,390 marks, and from the department of public works 4,000 marks, from the Mecklenburg-Schwerin Government 400 marks, from the Grand Duchy of Oldenburg 800 marks, from Wuertemberg 600 marks, and from Bavern 1,000 marks. These sums were used principally in the development of the chief peat districts.

Demonstration farms were operated in 320 places, covering seven Prussian provinces and six other states of the Empire. These demonstration farms fulfilled their purposes, as several owners of peat lands brought their deposits under cultivation after studying the exhibits. The cost of these demonstration farms was 40,000 marks. The activities of the technical section covered trials in Holland of the use of powdered peat, where it was shown that powdering the peat doubled its heat value. Trials were conducted with peat coke in various heating devices.

The rest of the meeting was devoted to a paper by Prof. Tacke of Bremen on the effect of the war means on peat agriculture and to a paper by Rotberg on the use of war prisoners in the agricultural development of peat lands.

FEDERAL CO-OPERATIVE WORK ON AGRICULTURAL MUCK.

Copy of Memorandum Between Bureau of Plant Industry and American Peat Society.

To give proper attention to this important work a Committee of Agriculture was appointed by the Executives of the American Peat Society consisting of: Mr. Charles A. Crouse, Syracuse, N. Y.; Mr. John N. Hoff, 17 Battery Place, New York City; Prof. H. C. Thompson, Dept. of Agriculture, Washington, D. C.; Mr. Paul H. Todd, 323 North Rose Street, Kalamazoo, Mich.; Mr. John Wiedmer, 621 Pierce Bldg., St. Louis, Mo.

This Committee put into operation the agreement made with the Bureau of Plant Industry.

The work was begun on a tract of approximately four acres of cultivated muck soil located at Great Meadows, N. J., this being considered a good representative of that quality of agricultural peat or muck.

Professor Thompson has been in charge on behalf of the Bureau of Plant Industry and is now completing the third year of experiments and at least a preliminary report of the work thus far done is expected soon from his Department for the benefit of the general trucking industry on this class of soil.

During this period greenhouse work has also been carried on at the Arlington farms of the Bureau of Plant Industry, Washington, D. C., to determine the value of agricultural muck or peat when used in growing greenhouse vegetables and flowers. Much valuable material has already been collected as a result.

Muck or peat has been used there from the Great Meadows, N. J., deposit, as well as from the Todd farms, Mentha, Mich.

Field work was started this year also in Indiana under the same co-operative plan and it is hoped to extend it to other sections of the country with a view to classifying the various agricultural muck soils and to determining the best and most economical method of fertilization and general treatment and the best and most profitable crops that can be grown thereon.

It is believed that the American Peat Society should take the keenest interest in the co-operation and should assist in every way possible in making it a success.

Work of this character should appeal to every one growing muck-soil crops, increase interest in the Society, and greatly benefit the entire agricultural community.

Prof. H. C. Thompson will gladly give some of the details of the work thus far accomplished.

Memorandum of Understanding Between the American Peat Society and the Bureau of Plant Industry, U. S. Department of Agriculture, Relative to Co-operative Work in the Agricultural Utilization of Organic Soils.

(To take effect June 16, 1913.)

The objects of this co-operative work shall be to conduct tests to ascertain the crops, methods of culture and treatment necessary to the successful utilization of the peat, muck, and other types of organic soils, existing in the United States.

In conducting these investigations it is understood that the following plan shall be pursued:

(1) The American Peat Society, of New York, agrees (a) to furnish a sufficient area of each of the different types of soil in various parts of the country in which to conduct these experiments; (b) to provide for use in greenhouses at the Arlington Experimental Farm such muck soil as may be required for conducting experiments under greenhouse conditions; and (c) to furnish the necessary labor for the cultivation of the crops to be grown on the several areas.

(2) The Bureau of Plant Industry, with the approval of the Secretary of Agriculture, accepts the invitation to co-operate in this work extended by the Executive Committee of the American Peat Society, as outlined in its letter of April 25, 1913, and agrees to detail a representative to personally supervise and direct the investigational work to be inaugurated by the Bureau under this memorandum, pay his salary and traveling expenses and provide him with such office supplies and technical equipment as may be required, and furnish for these experiments such seeds, plants and fertilizers as may be required.

(3) Detailed plans for proposed lines of investigation shall be formulated by the Bureau of Plant Industry after consultation with the Executive Committee of the American Peat Society and, when approved by the Executive Committee, these plans shall be put into operation under the supervision of the representatitves of the Bureau of Plant Industry.

(4) Such reports of the experiments as may be prepared shall be made in duplicate and one copy furnished to each of the co-operative parties, but data regarding the work shall be published only upon authority of the Bureau of Plant Industry.

(5) Upon the conclusion of this co-operative work, it is understood that the Bureau of Plant Industry shall be at liberty to remove from the premises of the American Peat Society upon which such experiments shall have been made any equipment, apparatus, or valuable plants which it has furnished in the course of these investigations.

(6) This memorandum of understanding shall take effect June 16, 1913, and remain in effect until rescinded by either or both of the parties concerned, it being understood that the nature of the investigations is such that the work must continue for five

or more years in order to be productive of sufficient data on which to base definite recommendations.

(Date) ....

President, American Peat Society.

(Date) ....

Chief, Bureau of Plant Industry,
U. S. Dept. of Agriculture.

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The value of Peat Fuel, as compared with coal, for production of Power*

By B. F. Haanel

The subject of this paper, "The Value of Peat Fuel, as Compared With Coal, for the Production of Power," is one about which much has been written, but the extravagant claims made for the efficiency of peat when used for the production of power have not tended towards enlisting the favor of power producers in this class of fuel, for the reason that few, if any, of the claims have been substantiated.

When considering the cheapest and most economical fuel to use for the production of power for any purpose whatever, it is customary to compare those fuels that can be bought on the market or are easily available. Peat most emphatically cannot be classed as one of these, notwithstanding the large number of papers written on the subject of peat-fuel manufacture and the numerous prospectuses issued from time to time for the purpose of extracting in the most plausible manner the hard earned savings of credulous investors. The methods employed for promoting peat-fuel manufacturing companies are, perhaps, responsible more than any other factor for the little progress made in establishing this important industry. We are all familiar, of course, with the many processes that have, from time to time, been advanced for the manufacture of peat-fuel which have been successful only from the standpoint of the speculator and promoter. Nearly all of such processes were doomed to failure from the very start, for the reason that they were based on wrong principles. Almost any competent engineer, possessed

*Read at the ninth annual meeting of the American Peat Society, Detroit, Mich., September, 1915.

of some practical knowedge of peat, of its properties, and its manufacture, could have prevented the waste of capital on these ventures if he had been consulted, or if those interested had been desirous of heeding the advice of many qualified peat engineers who have given their expert opinions gratituously to the public. For these reasons the title of this paper will appear, to not a few, most startling in as far as the United States and Canada are concerned.

It would, therefore, appear most logical, before an effort is made to compare peat-fuel with coal as a source of power, to outline the method most likely to result successfully in the establishment of a peat-fuel industry.

Peat, as it exists in the average bog, contains upwards of 87 per cent. water, 7 per cent. combustible matter, and a varying percentage of ash. So when considering the feasibility of converting this exceedingly low-grade substance into a marketable fuel to compete with coal, consideration must be given to the fact that for every 10 pounds of combustible matter more than 100 pounds of raw material must be excavated and handled in various ways before the 10 pounds, or fraction thereof, is available. Now it is quite apparent, even to the layman, that all the moisture can be removed from the raw, wet peat, through the agency of artificial heat, and that a large portion can be removed by pressing in specially constructed presses. It is further well known that such peat dried down to 10 or 13 per cent. moisture can be briquetted into an excellent looking fuel without the addition of a binder. In fact, almost everyone interested in peat is aware that this low-grade substance can be converted into a substance resembling coal. It is necessary therefore only to consider three different methods for separating the moisture from the raw substance and ascertain their economic practicability. The different methods of evaporation of moisture will be enumerated and dealt with in the following order:

(a.) Application of artificial heat.
(b.) Pressing in hydraulic presses.
(c.) Heat of the sun.

The evaporation of the water content through the agency of artificial heat implies the necessity of generating a definite quality of heat by burning some kind of fuel. Apart from the physical properties of peat which render the separation of the contained water by heat more or less difficult, the theoretical quantity of heat required to evaporate 1 pound of moisture will be 1122 B. t. u. This figure is obtained as follows:

Latent heat of water per pound........... 970 B. t. u.
Heat required to raise 1 pound of water

from 60° F to 212° F................ 152 B. t. u.

1,122 B. t. u.

This means that theoretically the quantity of heat required to reduce the moisture from 100 pounds of peat containing 90 per cent. moisture from 90 per cent. to 25 per cent. will be:

$$1120 \times 86\,2/3 = 97{,}100 \text{ B. t. u. (approx.)}$$

The quantity of heat available in raw peat substance, assuming the calorific value of the absolutey dry peat to be 9,000 B. t. u. per pound, would be:

$$10 \times 9{,}000 = 90{,}000 \text{ B. t. u.}$$

To reduce the moisture from 90 to 25 per cent. will, therefore, require 97,000 B. t. u. As the quantity of heat available in raw peat is 90,000 B. t. u., a balance of 7,100 B. t. u. must be supplied in addition to the total heat energy of the fuel. These figures are theoretical; in practice the value 7,100 might be easily one-third greater. It is unnecessary to dwell upon the absurdity of drying peat from 90 per cent. to 25 per cent. moisture by the application of artificial heat.

Pressing in Hydraulic Presses.

When peat is of a fibrous character, the water content of the raw peat can be reduced from 90 to about 75 per cent. in almost any well-constructed hydraulic press—in fact this has been accomplished in Italy with the employment of an ordinary hay press. The great difficulty is experienced when the attempt is made to reduce the moisture below 75 per cent. All efforts to reduce the moisture below 75 per cent. by means of presses alone have not met with economic results. The impossibility of carrying out this further reduction of moisture has been found to be due to the chemical constitution of the peat which must be changed before further water can be separated by pressing. For the purpose of altering the chemical constitution of peat in such a manner that it would part with its moisture by pressing, Ekenburg devised his "wet-carbonizing process," but though the quantity of water that could be pressed from peat treated according to this process was notaby increased, even this process has not, up to the present time, proved feasible.

The next method to consider would logically be a combination of **a** and **b.** The first step would be to separate as much water as possible by pressing, and then to reduce the moisture of the pressed substance by means of artificial heat until sufficiently dry for industrial purposes.

Let us examine this method and ascertain the quantity of heat that is required to dry the pressed peat sufficiently for use in the gas producer or steam generator. It will be assumed that

the peat in this case must have a moisture content not exceeding 25 per cent., and that by pressing alone the moisture content of the original wet peat is reduced from 90 to 75 per cent.

First. One hundred pounds of wet peat contains 90 per cent. water, and 10 per cent. dry peat substance.

Second. By pressing, moisture is reduced from 90 to 75 per cent., 60 pounds of water being expelled from the 100 pounds of peat.

Third. Evaporation of 26 2/3 pounds of water from pressed peat in order to reduce the moisture content to 25 per cent.

The latter case will be considered, namely, the quantity of heat required to evaporate 26 2/3 pounds of water:

Quantity of heat required to evaporate (theoretical)

$$26\,2/3 \times 1120 = 29{,}900 \text{ B. t. u. (approx.)}$$

Assuming 70 per cent. thermal efficiency of dryer:

That is to say, in order to obtain 13 1/3 pounds of peat containing 25 per cent. moisture, 5 pounds of absolutely dry peat must be burned. It is clear, therefore, that such a process is in no sense economic.

The last method to be considered is that depending on the sun's heat and wind for the evaporation of the moisture. Such a process is dependent on atmospheric conditions, but is the only one that has proved feasible and is used for the manufacture of the large quantities of peat produced in Europe. The quantity of peat fuel manufactured in Europe amounts to several millions of tons per annum, and of this production a large part is used for industrial purposes. Many difficult problems have been solved during the evolution of the peat industry in Europe, making possible the utilization of this low-grade fuel for the production of power in competition with coal. But in order to compete with coal, peat must be manufactured at a cost that will permit it to be sold, at a profit, considerably below the market price of coal. This statement pertains principally to the utilization of peat fuel for the generation of steam. When it is employed for the production of power gas, many interesting factors must be considered which under favorable circumstances permit its market price to be considerably increased. This feature is considered in more detail later.

In the light of what has been accomplished in Europe, it is safe to make the statement that peat fuel can be manufactured on a sufficiently large scale on the North American continent, to permit its competition with coal for the production of power under certain favorable conditions.

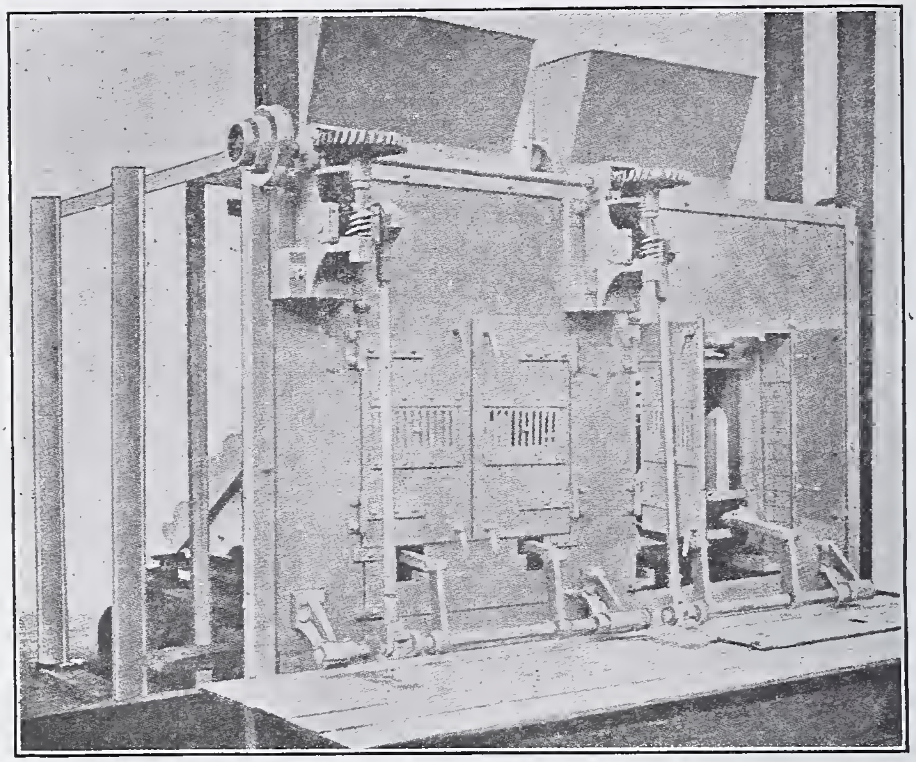
The conditions under which peat-fuel can compete with coal are principally the proximity of peat deposits to points of con-

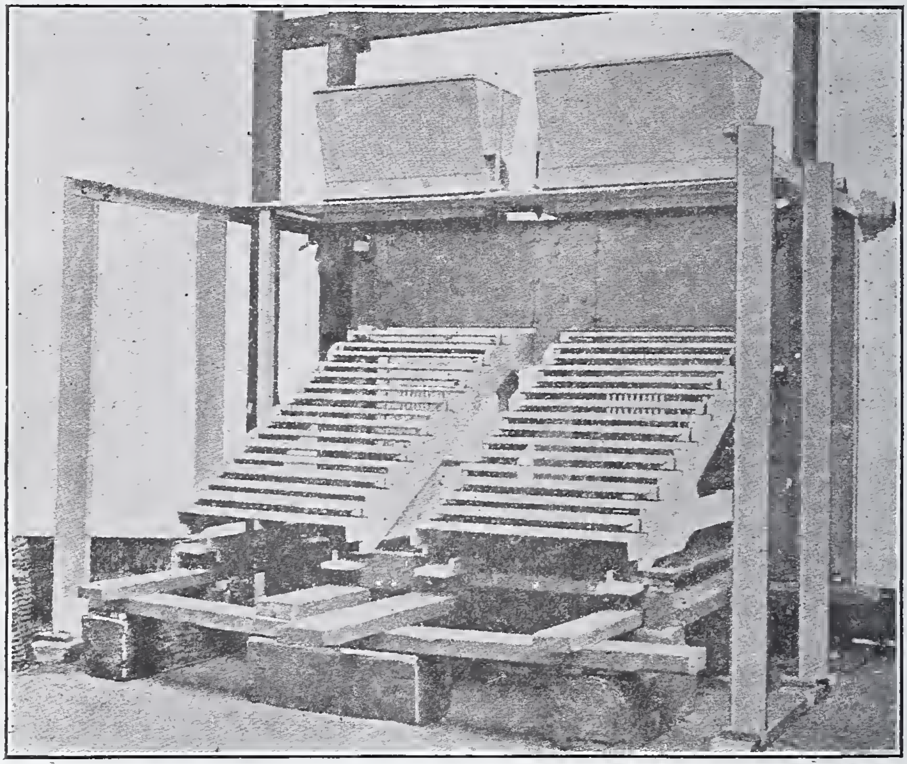
sumption, and a high cost of coal, owing to distance of coal mines from points of consumption. Water powers are not considered in this connection, as it is assumed in this paper that coal or peat are the only available sources of energy for the generation of power.

The above remarks apply particularly to the production of power from steam and from fuel, when utilized in the gas producer without by-product recovery. When by-product recovery in connection with the gasification of a fuel is considered, many important factors arise, which greatly alter the comparative value of the two fuels. The utilization of peat fuel for the production of power through the media of steam generators and steam engines cannot be considered a serious competitor with coal under any conditions where coal is obtainable at a reasonabe cost. But in isolated places too far distant to permit the economc delivery of coal, a well-situated and suitable peat bog may be employed to great advantage.

Peat can be burned as efficiently as coal in properly designed steam generators, the principal disadvantages of the former being the comparatively low heating value, larger volume occupied per heat unit, and the difficulty of handling and storing the requisite quantity of fuel for an uninterrupted year's operations. On the other hand the small amount of ash and inappreciable quantity of combustible matter contained in it, render peat more suitable than coal. but the latter advantage is scarcely worthy of consideration when weighed against the many disadvantages it possesses.

The only large steam-power plant designed for the exclusive use of peat fuel. of which the writer has any details, is that of "The Siemens-Schuckert Company," on the Wiesmoor, in Ostfriesland, Germany. This plant is equipped with specially designed steam generators and steam turbines and has a capacity of over 5,000 horsepower. The steam generators are supplied with step grates and large combustion chambers similar to those of the Babcock & Wilcox boilers (Fig. 1). The peat fuel is handled mechanically from the storage bins to the boilers, thus reducing to the greatest extent the employment of manual labor. With peat fuel costing $1.20 per ton, the price at which it is said the German Government sells the fuel to this company under contract, the steam plant is able to generate power more cheaply than with coal costing $3.50 per ton. The policy of the German Government has been one of conservation and encouragement in the utilization of its natural resources in the most efficient manner, and this plant, it must be borne in mind, was an integral part of the scheme of the Prussian Government for converting this large peat moor into fertile farm land. In this respect, it has met with admirable success, but it is scarcely probable that





Peat-burning furnace, with moveable bars, as applied to Babcock & Wilcox boilers.

private companies could have carried to completion such a vast and original scheme without government assistance.

Boiler Efficiency.

Tests conducted at this plant showed that a thermal efficiency of 73.5 per cent. for the steam generator could be realized; this is equivalent to an evaporation of 3.01 kilograms of water per kilo of peat, or 3.01 pounds of water per pound of peat. The average calorific value of the peat burned was 4.824 B. t. u. per pound, which, it might be remarked, is low compared with that determined for many of the Canadian peats, so far examined. The moisture content of the peat fuel, of course, varies, but an effort is made to keep the average in the vicinity of 30 per cent.

The above result cannot be realized in every day operation. Up to the time the plant was visited by the writer, it had been possible to attain a consumption of only 2.7 kilos (5.94 pounds) of peat per kilowatt-hour in rare and isolated cases. A consumption of 2.4 kilos (5.28 pounds) of peat has in fact been obtained. In wet weather the fuel consumption averages 3 kilos (6.6 pounds) per kilowatt-hour.

If the cost of peat per ton is taken as 5 marks ($1.20) per ton, a fuel consumption of 2.4 to 2.8 kilos (5.28 to 6.16 pounds) per kilowatt-hour would cost 0.3 to 0.35 cent per kilowatt, which at that place would be about the same price as when coal is burned.

From the foregoing, it will be seen that peat fuel can be utilized in competition with coal for the production of power in steam plants, but only when the most rigid economies are introduced both in the manufacturing and handling of the peat fuel and in the conversion of its heat energy into useful work.

The second method for the production of power from peat that will be considered is the conversion of the heat energy of a fuel into a combustible gas through the medium of a gas producer and the employment of this gas in a gas engine. This method is by far the most efficient, and appears especially attractive, and the most desirable one to employ for this class of fuel.

The production of power or fuel gas by means of gas producers may be divided into two main classes:

First. Production of gas without by-product recovery.

Second. Production of gas with by-product recovery.

The producers included in the first class are known as non-by-product recovery producers, and those of the second class as by-product recovery producers.

Non-by-product Recovery Producers.

In non-by-product recovery producers the aim is to convert all the combustible components of a fuel into a combustible gas.

No attempt is, therefore, made to recover such by-products as tar or ammonia. In fact, such by-products should not occur in the theoretical sense when the producer is properly designed for the most efficient gasification of the fuel, which in the case considered is, of course, of the bituminous variety. But though efforts have been made to convert all the combustible matter of peat, for instance, into gas, the results have not been entirely satisfactory, as certain quantities of hydrocarbons always escape gasification and pass off as by-products. With this type of producer, excellent results have been obtained both with bituminous coal and peat fuel, and as the data available concerning tests of both of these fuels are rather comprehensive, it is possible to compare their value for the production of power gas.

The cost of a power plant for either of these fuels will be approximately the same, and the labor costs at the power plant cannot vary to any appreciable extent. It is therefore possible to estimate the probable economics arising from the use of one or the other fuel by comparing the consumption and cost of fuel per brake horsepower-gear.

The consumption of coal, bituminous or anthracite, in a well-designed producer-gas power plant, may be put at 1½ pounds for actual commercial operations—better results than this can be realized, and perhaps in a few cases have been obtained even in commercial practice. For peat fuel, it has been found as a result of a large number of trials conducted under varying conditions, that 1 brake horsepower-hour can be produced from 2 pounds of peat containing 25 per cent moisture. For purposes of comparison, the consumption of peat per brake horsepower-hour will be taken as 3 pounds. From this it will be seen that the quantity of peat required to produce 1 brake horsepower-hour is twice that of coal; hence, to compete on even terms with coal, other things being considered equal, the peat fuel must not cost more than half as much as coal. The market price of coal is therefore the deciding factor in determining the feasibility of generating power from peat.

The utilization of peat for power purposes in localities where coal can be purchased at a moderate price, or where low grades of coal, such as slack and screenings can be obtained, is entirely out of the question. But, on the other hand, there are numerous localities where coal for industrial purposes can be obtained only at a high price—in Canada this is especially pertinent. In such cases, peat might be the most economical fuel to employ, and its value as a fuel for the production of power naturally increases directly with the increase in the cost of coal, and the decrease, of course, in the cost of manufacturing at the bog. These comparisons hold only when the peat power plant

is situated on or very near the bog where the fuel is manufactured, as the cost of the fuel rises rapidly with the distance it is hauled. In considering the feasibility of erecting any power plant for the production of power from peat, the importance of providing storage space for the large bulk of fuel it is necessary to always keep on hand, ready for instant use, must not be overlooked. This factor is important, especially in cold and damp climates, and the necessity of a large storage space may, under certain conditions, mitigate against the economic employment of this kind of fuel.

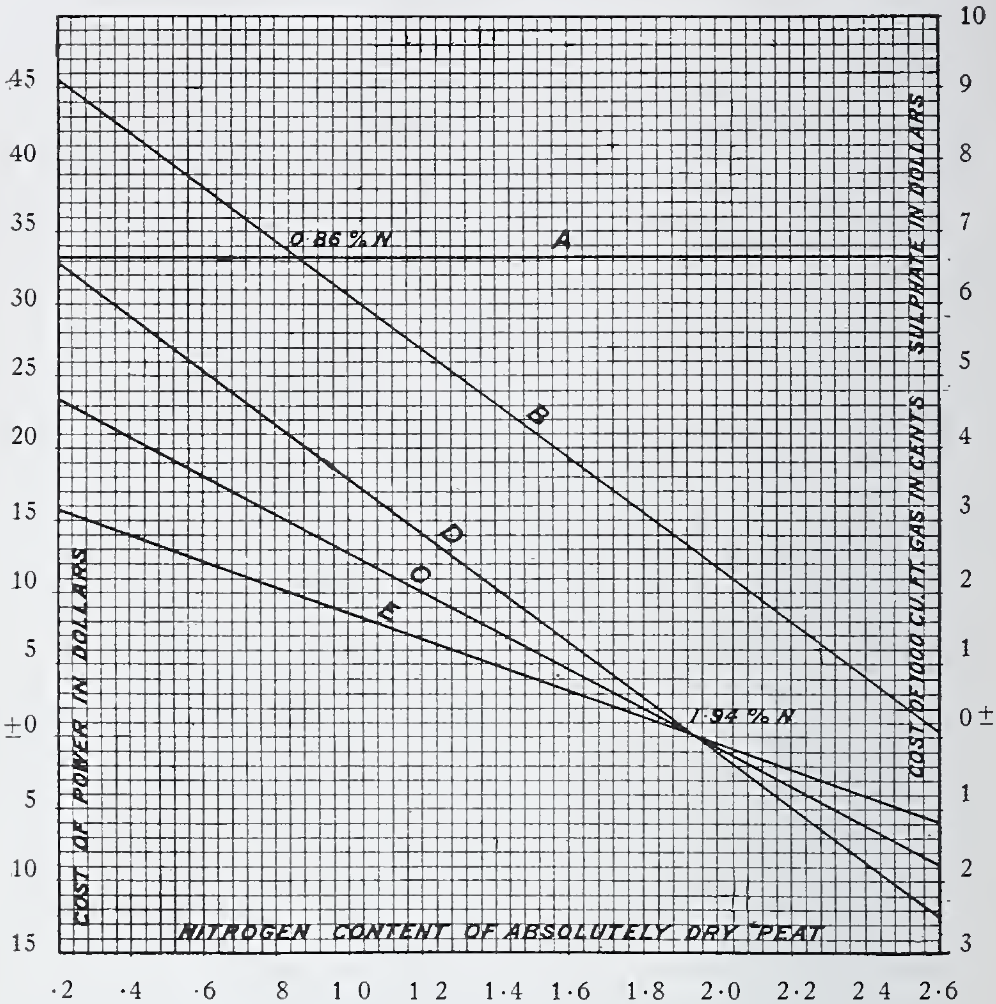
The Utilization of Peat in By-product Recovery Producers.

When a gas producer is designed to gasify a fuel in such a manner that the greatest quantity of by-products is obtained, the producer is termed a by-product-recovery producer. When such a type of producer is used, its efficiency as a power gas producer is sacrificed to a certain extent in favor of the by-product-recovery efficiency. Such a producer can, therefore, be employed only when the recovery of by-products proves a profitable venture outside of, and in addition to, the production of power or industrial gas.

The by-products obtained when fuel is gasified in this type of producer are principally ammonia and tar, and of these two the ammonia is of the greater value. It is consequently apparent that the value of this process increases directly with the quantity of ammonia obtainable with its use. Ammonia is a chemical compound composed of nitrogen (N) and hydrogen (H), and has the definite chemical formula NH_3. The nitrogen is obtained from the fuel and the hydrogen is obtained by the decomposition of steam when this is brought into contact with hot carbon. This reaction is a part of the process of gasification. Therefore the fuel that contains the largest amount of nitrogen is the most valuable for utilization in this manner. However, the ammonia thus formed is not recovered as ammonia, but is caused to react with sulphuric acid in such a manner that all or very nearly all is converted into sulphate of ammonia according to the reaction:

$$2NH_3 + H_2SO_4 = (NH_4)_2SO_4.$$

From the molecular formula $(NH_4)_2SO_4$, the ratio of the pounds of ammonia sulphate to the pounds of nitrogen is found to be 4.7, that is, the quantity of ammonium sulphate formed is 4.7 times the quantity of nitrogen entering into combination. For example, if a ton of coal (2,000 pounds) has a nitrogen content of 1 per cent., the quantity of nitrogen is 20 pounds, and the ammonium sulphate that can be formed is $20 \times 4.7 = 94$ pounds, a value that, of course, is theoretical, the quantity



Curves illustrating effect of increase of nitrogen content on cost of generating power from peat.

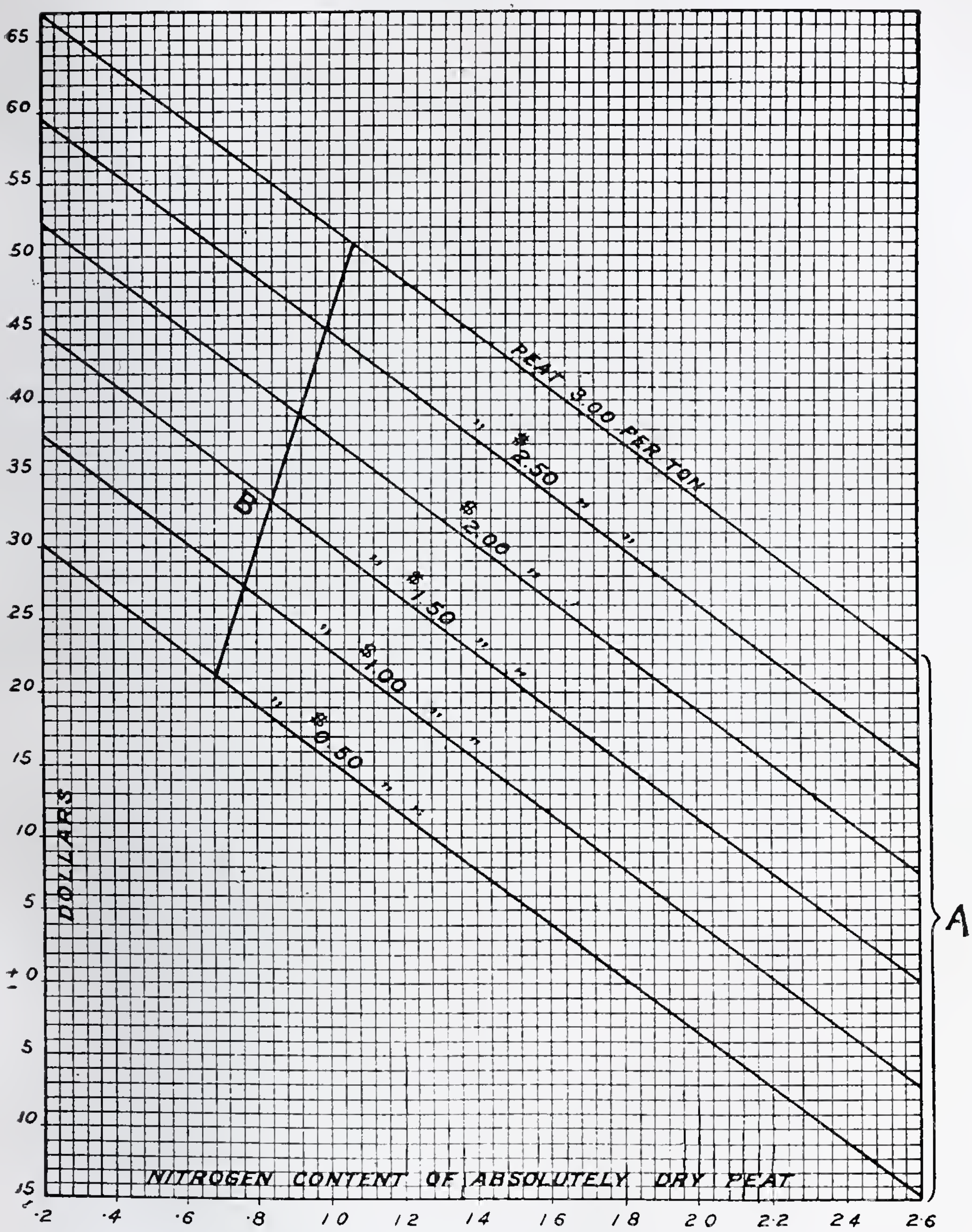
A Cost of producing 1 brake horsepower-year with non-by-product recovery peat producer gas plant.

B Cost of producing 1 brake horsepower-year with by-product recovery peat producer gas plant.

C Cost of producing 1000 cubic feet of gas with by-product recovery peat producer gas plant.

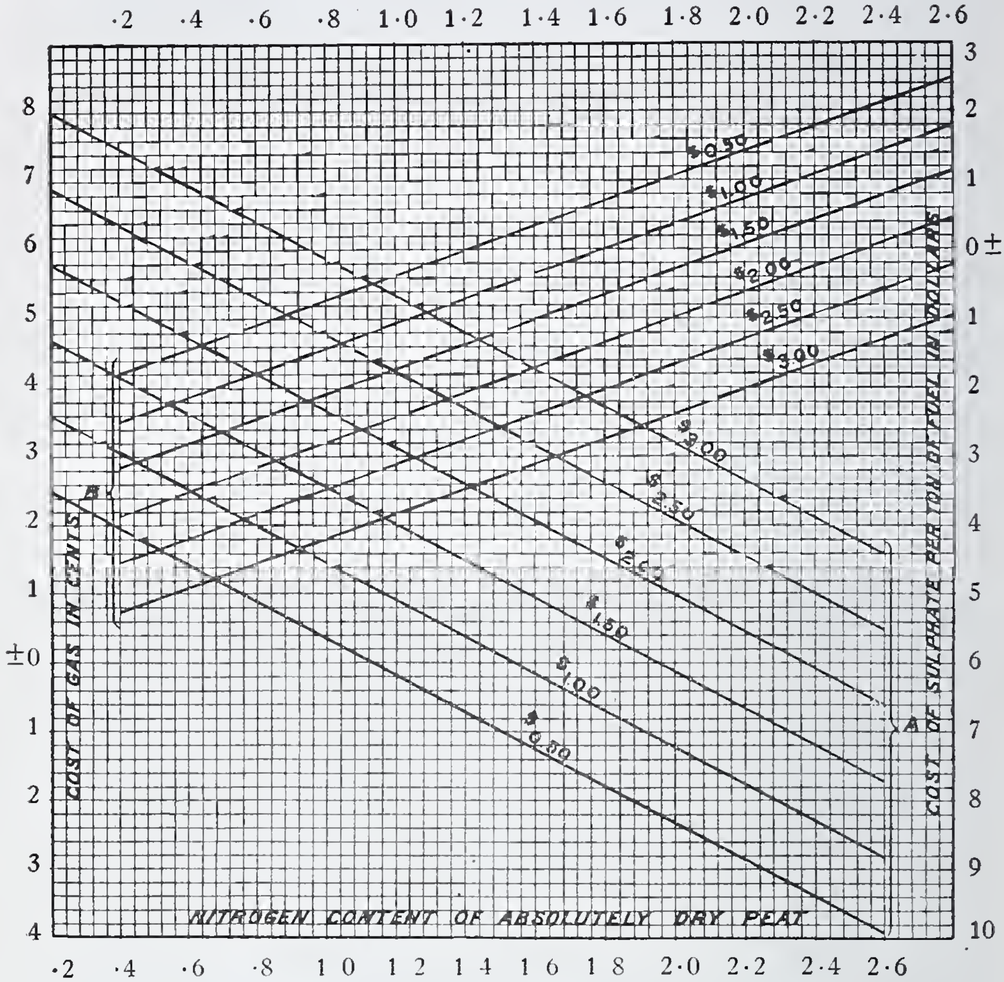
D Cost of producing gas for 1 brake horsepower-year with by-product recovery peat producer gas plant.

E Net cost of recovering ammonium sulphate per ton of absolutely dry peat gasified.



Curves A show the effect of increase of fuel costs on cost of power. Curve B shows the nitrogen the fuel must contain in order to permit by-product recovery plant to compete with non-by-product recovery producer-gas power plant.

NITROGEN CONTENT OF ABSOLUTELY DRY PEAT.



Curves A showing cost of 1000 cubic feet gas when peat costs $0.50 to $3.00 per ton.

Curves B showing cost of sulphate when peat costs $0.50 to $3.00 per ton.

actually obtained in practice rarely exceeding 75 per cent. of this.

Many of the peat bogs so far examined in the Provinces of Quebec and Ontario in the Dominion of Canada contain peat that has a nitrogen content averaging 2 to 2.5 per cent., and when the nitrogen content is as high as this, the by-product recovery process can be employed to advantage. The accompanying curves taken from the report on "Peat, Lignite, and Coal: Their Value as Fuels for the Production of Gas and Power in the By-Product Recovery Producer," show the great

effect of the nitrogen content on the cost of producing power gas and power. The plant and labor costs on which these curves were calculated are considered by the writer to be conservative. But although this method of producing power or industrial gas is most attractive and offers liberal profits when all goes well, the strictest economies, especially in the manufacture of peat fuel, must be introduced in all except such cases where the nitrogen content is over 2 per cent. The curves shown in figure 2 illustrate the latter point.

Plants of the above description are in successful operation in Italy, and are utilizing peat bogs from which the winning of the fuel is difficult and which produce a fuel of comparatively low nitrogen content—about 1 per cent. There is no good reason why the peat bogs of North America, especially those in the inhabited regions of Canada, cannot be utilized for this purpose, as many of them contain peat with a high average nitrogen content.

In conclusion, it may be stated that peat fuel can be utilized for the production of power in either steam or producer-gas power plants as efficiently as can coal, and that the price at which coal can be bought and that at which peat fuel can be manufactured are the principal factors to be considered.

It is manifestly in the interest of the conservation of our "natural resources" to utilize this low-grade fuel, which is so abundantly distributed throughout the world, but the cause of conservation, which is a most just and necessary one, must not be used as a pretext for promoting wild schemes for the utilization of this substance.

DISCUSSION.

B. Von Herff: Are any peat gas power plants in operation in Canada?

Mr. Haanel: None that I know of, except the Government plant at Ottawa.

B. Von Herff: For want of capital?

Mr. Haanel: Yes; no money for 10 per cent. investment.

Prof. Davis: Mr. Haanel's paper is a most valuable contribution. He has at his disposal valuable experimental data and speaks with authority. I don't know of any more important work done anywhere along the line of the subject on which he addressed us than that of Mr. Haanel. It is unfortunate that investors cannot be induced to take up carefully thought out and business-like propositions to develop peat. It appears there is not enough excitement involved in investing, say, $100,000, and having it returned in 10 per cent. bits, with practically no chance of failure. If some promoter comes to them with a proposition to turn out fuel briquets at $1 a ton, then they listen.

Mr. Kleinstueck: From personal investigation I am convinced there are places in the United States where very satisfactory power installations using peat could be made to the advantage of the capitalists investing and the community, and where important industries could be profitably based on raw materials now going to waste. All that is now needed is confidence. Processes for the use of peat for power production have been developed which make it commercial. Water power is not everywhere available, and in those places where it is, it is more expensive in many instances than has been claimed. The Society should exert all its influence towards endorsing the legitimate development of large power plants on suitable bogs.

B. Von Herff: Can Mr. Haanel give any information as to the returns obtained on the capital invested in peat power plants in Germany?

Mr. Haanel: Unfortunately it has proved almost impossible to secure information with regard to the operation of such plants in Germany. There is reason to believe that the Osnabrück plant has not been a success. Apparently the selection made of a bog was not good. The latest advices, however, indicate that steps are to be taken to place the undertaking on a paying basis. The only reason it has been successfully operated by Siemens & Schuckert is that they get peat guaranteed by the Government at $1.20 a ton. The Government may be losing money in supplying the peat at that price, but on this point I have no information. On the Wiessmoor the operations pay owing to the special conditions prevailing there.

Prof. Davis: The Government contractor at Osnabrück has stated in conversation with me that he had a profit of 1 mark per ton.

B. Von Herff: If peat with 1 per cent. nitrogen pays in Germany, it should pay well to develop in this country peat containing 2½ per cent. nitrogen.

Mr. Kleinstueck: Has Mr. Haanel taken into account the great difference in wages between this country and Europe?

Mr. Haanel: Yes. Curves have been prepared to accompany my paper, and will be handed to the Secretary for publication along with it, calculated on the basis of the generally prevailing wages in most parts of the United States and Canada, and on an 8-hour day.

Mr. Kleinstueck: In some parts of Europe wages are very low, perhaps not exceeding 25 cents per day.

Mr. Haanel: I have not figures at hand, but the wages paid at Osnabrück were reasonably high—not a great deal lower than at the Mond plant in England.

A Member: What percentage of moisture in the peat fed to the producer have you found most practical?

Mr. Haanel: We try to keep down to 25 per cent. moisture, but have fairly good results with a moisture content as high as 33 to 35 per cent. Twenty-five per cent. gives the best results. I visited the installation at Pontedera, Italy, two years ago, and found that there they kept the moisture down to 25 per cent. At Wiesmoor the fuel used averaged about 33 per cent. Trouble was experienced when it went much higher than that.

The Value of Humus in Soils

By Prof. H. C. Thompson *

The crop-producing power of the soils of the United States has been greatly reduced during recent years through the exhaustion of the humus content of these soils. When our American soils were first cultivated, they contained large quantities of organic matter, commonly referred to as humus, but the cropping methods followed by the American farmer have tended to greatly exhaust this soil property.

The members of this Society have, during the past, been in the habit of considering the vast beds of peat, or humus, soils in the northern and northeastern States and in Canada in connection with their commercial and manufacturing uses. It is only within the past few years that persons holding an interest in these vast deposits have begun to realize their agricultural value and true nature. In order that we may get a little more definite idea of their agricultural value, it might be well for us to consider briefly the part played by humus, or organic matter, in farm lands, and some of the methods by which this organic matter may be obtained.

As already suggested, the virgin soils of America were rich in organic matter. The greater portion of the land was covered with forests. The enormous amount of vegetable matter, or humus, in the soil furnished it with an abundant capacity to absorb and retain moisture, thus preventing the erosion of the land and the quick drainage of the water. In this way, floods were prevented, the springs and streams had a uniform, steady flow, and the land was free from the disasters of flood that have recently befallen it. Even in the swamp areas where great beds of peat or humus soils abound, drainage has been provided and the water now runs off quickly, adding to the conditions that bring about floods along the river valleys.

The problem that confronts the American farmer today is how to replace in his soil the wasted organic matter. In this connection, the great muck beds of the north and northeast are wonderful sources of wealth, especially as regards the restoration of the organic matter in the soils of the neighborhoods where they exist. Chemical analysis and crop tests have shown these muck soils to be extremely rich in nitrogen, and therefore valuable as a source of nitrogen for worn out land. Based on the values of commercial fertilizer, many of the peat deposits are worth about $6 to $8 a ton for their nitrogen alone. About $100,000,000 is spent annually by the Southern, or cotton States for fertilizer, the greater portion of which

*Read at the Detroit Meeting.

contains no larger percentage of nitrogen than the best of the peat soils. This will give some idea of the enormous value of peat, or muck, for use on lands within reasonable shipping distance of the deposits.

The farmer has recourse to other methods of restoring the organic matter in his soils—first, by means of leguminous crops, these, as a rule, to be preceded by applications of lime and the proper bacterial inoculation. Among the crops most commonly used for this purpose are red clover, white clover, Swedish or Alsike clover, sweet clover or Mellilotus, alfalfa, cow peas, soy beans, and a wide range of this class of plants. In addition to supplying actual organic matter to the soil, the legumes have the power of drawing the nitrogen from the air, and storing it in the soil, thus serving a double purpose. Both nitrogen and organic matter are, however, abundantly present in the muck, or peat, soils, and for this reason they are valuable as soil builders. When clovers and other legumes are used for adding organic matter to the land, this material is in a raw state, and must go through a period of decomposition before it is available for plant food, whereas the peat, or muck, drawn from the beds and applied to the land is in available form, except in cases where it is in acid condition for want of exposure to the air, or the addition of lime.

The addition of organic matter to farm lands not only adds plant food and increases their crop producing power, but also makes the land more receptive and retentive of moisture; in other words, a soil that is lacking in humus dries out quickly, whereas the soil that is filled with organic matter absorbs the water as it falls and retains it for a much longer period, in this way keeping the plants supplied with the necessary amount of moisture.

Few persons appreciate the value of peat, or muck, for use in preparing or treating soils for special purposes. I refer especially to the matter of greenhouse and intensive gardening soils. In 1888, the Ohio Experiment Station, then located at Columbus, Ohio, began the use of muck soil in their vegetable forcing houses, and it was soon apparent that this soil was far superior to the ordinary sod loam and manure mixture ordinarily used, although the peat soil was found to be lacking in potash and phosphoric acid. Since that time, the use of muck soils for greenhouse work has grown in popularity, and this material is now used as a mixture with other soils by a large number of gardeners. There are many greenhouse men, however, who have not learned the true value of muck for use in their greenhouses, and there is need for a campaign of advertising to promote the use of this material by greenhouse men. The gardeners of France and England have built up their soils by the excessive use of decayed stable manure, and in so doing have obtained practically the same results as we can secure by the application of peat, or muck, especially where used in conjunction with the manure.

The time is rapidly coming when every available ton of muck soil in this country will be in demand for soil building, for restoring wornout soils of the northeastern States to their original crop-producing capacity, and also for supplying a suitable soil for use in connection with the enormous acreage of glass now being devoted to the production of winter crops in the North. The use of this material for fuel and manufacturing purposes is an unquestionable waste, and should be stopped, and it is within the province of this Society to so mold public opinion and educate the people to a proper and economic use of so great a natural resource.

The value of peat soils for the production of celery, lettuce, and similar crops has been underestimated by most people. That greater results have not been obtained has been due to a lack of understanding of the nature and requirements of muck soils. Owing to the fact that these soils have in many instances been either under water, or saturated for years, they are deficient in the bacterial life required to transform plant food from the nonavailable to the available form. The application of manure to peat soils greatly benefits them from the standpoint of adding bacterial life. These bacteria will not thrive under conditions where the air is excluded by the presence of an excess of water in the soil, and drainage is just as essential as fertility. These same conditions cause muck soils to contain an excess of acid, this requiring correction both by areation and the application of lime.

Although muck soils are, as a rule, well supplied with nitrogen, many of them are deficient in potash and phosphoric acid, and these must be supplied from an outside source. Many gardeners have an idea that because the muck soils are black, they are necessarily rich, and do not need the application of manure or mineral fertilizers. The writer has thus far failed to observe a muck soil that has not been benefited by the application of liberal quantities of both organic and mineral manures. There is indeed great possibilities for crop production on the muck soils of America, and a duty devolves upon us to promote the conservation of every acre of these soils.

SOME LIMITATION ON THE CULTIVATION OF PEAT LANDS IN MINNESOTA

By F. J. Alway*

The results obtained during the past thirty years at the various European peat-experiment stations have fully shown the ability of peat soils, even those of inferior quality, to produce satisfactory crops of forage plants and small grains and all our ordinary vegetables, with the single exception of asparagus, when suitable cultivation and proper fertilization are employed, and when also the climatic conditions are favorable.

In speaking of successful farming on peat it is always understood that a satisfactory drainage system has been installed—one that holds the water far enough below the surface to prevent water logging and makes it possible for men and horses to work upon it and yet does not lower it to such an extent that the crops suffer from drought. In regions with a heavy rainfall, such as 60 to 80 inches per year, there is no danger of depressing the water too much, the crop plants doing as well on the sides of ditches 12 feet deep as elsewhere. However, in climates such as we have in Minnesota, the highest yields are obtained with the water at a depth of not more than 20 to 40 inches. The most favorable depth in given cases depends upon the particular crop to be raised.

The factors that, aside from climate, place limitations upon the profitable cultivation of peat land are the cost of labor, fertilizers and lime, the transportation facilities, which determine to a considerable degree, the actual cost at the bog of the fertilizers and lime, and finally the expense of marketing the products. All of these, except the climate and the character of the peat, are subject to sudden and radical changes.

The most extensive areas of peat land in Minnesota are in the northern, especially the north-central part, where there are millions of acres. Outside of these large tracts there are, scattered over the greater part of Minnesota, except in the southeastern and southwestern corners and large parts of the Red River Valley, innumerable small bogs, varying in size from a fraction of an acre to a section. In many places, especially on the edge of the Red River Valley, there are considerable areas where the peat is shallow, 8 to 15 inches deep, and there the land, soon after having been brought under cultivation, acts, in so far as crop yields are concerned, like an ordinary black loam. However, the extensive areas of the

*Read at the Detroit meeting.

north have in general a depth of 5 to 10 feet, or even more, and their treatment will have to be distinct from that of the ordinary soils.

As we have in northern Minnesota large areas of wild land with ordinary soil of good quality the peat can be profitably farmed only if it offers some distinct advantages over the mineral soils. One advantage is the possible lower cost of clearing, offset in part by the expense of draining. Another advantage, connected with the better type of peat soil, is the abundance of nitrogen. In ordinary soils this constituent is the one most difficult to maintain, whereas in good peat soils there may be sufficient nitrogen for centuries. A third, and probably by far the greatest advantage of all, is the unlimited supply of moisture available at all times on properly drained peat soils. An insufficiency of moisture is most frequently responsible for low yields of forage crops, even in northern Minnesota. The importance that this advantage of the peat soils may assume is evident, for it is just when the hay and pasture crops on the mineral soils are light, on account of drought, and the prices for these are high, that the bogs will be producing their heaviest yields.

There are some marked disadvantages shown by the peat soils. I refer now only to those on which the peat is so deep that the plants must derive their nourishment entirely from the peat layer. European experience has shown that all these soils, at least after a few years of cropping and commonly in the very first year, require an application of potash. Phosphates also are required by some, and on the poorer types a dressing of lime or ground limestone is needed, and also either a commercial form of nitrogen or the use of legumes as green manures. Stable manure, which is a complete fertilizer, supplies potassium, phosphorus and nitrogen, and may suffice for any peat, with the possible exception of one requiring a liberal application of lime, but as it in general can be used much more profitably on ordinary soils it is employed on peat only where the farmer has no ordinary soil, or is producing some crop that brings a high return per acre, such as celery or lettuce.

As the need for potash may be assumed to apply to all peat soils, whereas the need of phosphate and lime holds for only part of them, I shall confine myself to the potash problem in so far as fertilizers and soil amendments are concerned. The world's supply of potash for the past 50 years has been derived from Germany, and so just at present practically none is obtainable. Sulphate of potash, which ordinarily brings $55 per ton at St. Paul, can not now be had for $250. In the near future, however, a substitute for this German product may be developed from the beds of seaweed along our Pacific Coast, as a by-product of the manufacture of cement, or by some other method from the abundant supplies in our rocks. However, all these are matters of the future. For some years at least the potash to be supplied to our bogs will, on its way from the mines

to tidewater, pass close to the unreclaimed German peat lands, cross the ocean, and then make a long trip by rail. The result is that in the matter of this fertilizer our peat land farmers will be at a great disadvantage compared with those in Germany, Austria, and Sweden, all of whom are convenient to the supply. As a result we must look to that form of farming that requires the smallest applications in order to insure satisfactory returns after the initial dressing of potash. The one removing the least is stock production, or dairy farming. When the crop is pastured. little potash is removed, an annual application of 100 pounds of sulphate per acre having proved sufficient even for heavy pasturage, whereas twice that amount would be required for an ordinary crop of oats. If the grass be removed as hay and the manure produced from this be returned a somewhat heavier application of potash would be needed than though it were pastured off.

Labor cost is an extremely important item in bringing under cultivation those peat lands that are occupied by trees or by moss and shrubs, or in which large tree roots or logs occur near the surface. Although machinery may replace hand labor in digging the large ditches, the placing of hand laterals and the clearing of the surface of such bogs seem up to the present to be entirely dependent upon hand labor. At present on the bogs of Germany and Austria prisoners of war are being largely employed in reclamation work. The same practice was used in Germany during the Franco-Prussian war, and it was, in fact, the complete failure of the farming operations on the large bogs drained and prepared by the French prisoners during 1870-71 that led to the establishment of the first peat experiment station. Since that time there has been a growing sentiment in that country in favor of using all prison labor in the reclamation of peat lands. In Minnesota the labor problem in the preparation of these lands is serious, and we shall probably have to look to the development of powerful machinery, rather than to an improvement in the supply of manual labor.

Another limitation on the profitable cultivation of peat soils lies in the climate. In this we enjoy equal advantages with European countries. These soils are especially subject to summer frosts, which are distinct in origin from those on ordinary soils in low places. Those on the peat occur not because this occupies the lowest places, but because of its properties. These frosts may be prevented by coating the peat with a few inches of sand, clay or loam.

The climatic conditions on two bogs that are otherwise similar may be so different as to render crops and practices adapted to one entirely unsuited to the other. Only rarely do we find a station for weather observations situated on a bog, and the temperature records for one on ordinary soil do not give us any information as to the probable occurrence of these summer frosts on the bogs adjacent to the observation station. A good illustration is provided by the data for 1914 obtained at Grand Rapids. Thermometers for record-

ing maximum and minimum temepratures were placed in two shelters about 400 yards apart. The one was in the midst of the potato plots on the bog, a foot above the surface of the peat, and about 100 yards from the nearest mineral soil, and the other was on a hill 15 or 20 feet high. From the first of June until the 25th of September, the data of the first killing frost on the mineral soil, daily readings were made. Although temperatures of 29° to 31° F. were shown on four nights after August 26, no injury to vegetation on the mineral soil was observed until the severe frost of September 25. During this period the thermometer on the bog recorded a temperature below 32° F. on seventeen nights and on ten of these it was below 29° F. Many of these frosts injured the potato vines and tender vegetables, which we were not attempting to grow, would have been entirely killed. A tabulation showing a record of temperatures follows:

TABLE I.

Minimum Temperatures (° F.) in Observations During Season of 1914 at Grand Rapids, Minn., Experimental Farm.

Date.	Peat Soil.	Ordinary Soil.	Difference.
June 1	26	38	12
17	31	44	13
19	26	38	12
23	29	38	9
July 18	31	37	6
Aug. 11	27	32	5
15	31	39	8
16	31	50	19
24	27	33	6
27	27	30	3
Sept. 4	24	29	5
7	30	38	8
8	29	30	1
9	25	35	10
17	25	34	9
23	26	30	4
24	25	34	9
25	20	24	4

Although the minimum temperatures were almost regularly lower the maximum in general were slightly higher on the peat. On rainy or very cloudy nights the minimum on the bog was similar to that on the mineral soil. On clear, calm nights a low temperature on the mineral soil was apt to be accompanied by a frost on the bog.

The data on the mineral soil when compared with the normal, show that last year the growing season at Grand Rapids was longer

and somewhat warmer than the normal. From this consideration alone we might conclude that the number of summer frosts there last year probably was somewhat less than usual.

This conclusion, however, is not justified by data from European stations, which show that a comparison of the mean daily and monthly temperatures or even of the mean maximum and minimum temperatures furnishes us no definite information as to the occurrence or the relative frequency of these summer frosts. I shall take as an illustration data from the weather records of two peat experimental farms in Bavaria, in southern Germany, both operated by the Royal Bavarian Moorkultur-Anstalt. These two stations, Bernau and Karlshuld, are in large bogs, whereas within a few miles of each there is a weather bureau station on ordinary soil. Thus there are records on the two bogs and on the adjacent mineral soils that are available for comparison. As regards the two bog stations the monthly minimum and maximum temperatures were very similar, as the following tabulation shows:

TABLE II.

Mean monthly temperatures (° F.) on the bogs at Two Bavarian peat-land experiment stations.

	Normal.		In 1904.	
	Bernau.	Karlshuld.	Bernau.	Karlshuld.
January	23	27	38	28
February	31	32	35	34
March	37	38	37	38
April	44	45	48	48
May	54	54	54	54
June	59	60	61	61
July	62	62	66	67
August	61	61	62	62
September	54	53	51	52
October	47	45	46	46
November	36	36	34	34
December	31	31	32	33
Year	45	45	45	46

In passing I might mention that the precipitation at Bernau is much higher—two or three times as great—and the relative humidity during the growing season also somewhat higher than at Karlshuld. At Bernau where operations have been carried on for 20 years frosts appear to be unknown between the end of May and the first of September, whereas at Karlshuld frosts are liable to occur in every summer month and cause in almost every year more or less damage to the potatoes which are extensively grown there.

The experimental farms of Sweden furnish another illustration of the occurrence of summer frosts on bogs. The Swedish Society for Cultivation of Peat Lands has two experimental farms, one at Flahult and the other at Torestorp, at both of which weather records are kept. The climate differs from that in northern Minnesota in that it is cooler in the summer and warmer in the winter. On the bog at Flahult frosts have been recorded in every month of the growing season, but usually do not occur during July, whereas at Torestorp they are regularly to be expected in each month. At Torestorp a small sand hill projects from the surface of the bog and temperature readings are taken both on this and on the peat. The average number of frosts on the sand hill during the summer months is only 3, with none in July, compared with 9 on the surrounding peat soil with 1 in July. Tabulated data follow:

Frequency of frosts on two Swedish peat-land experimental farms.

	At Flahult.	At Torestorp.	
	On peat soil.	On peat soil.	On sand hill in bog.
May	14	13	9
June	3	5	1
July	0	1	0
August	1	3	2
September	8	10	7

We thus are not the only ones who have to meet the problem of frequent summer frosts. The European peat experiment stations that have this problem have been endeavoring to develop methods of meeting it. Theoretically the simplest method is to cover the peat with sand, clay, or loam, in this way presenting an ordinary mineral soil to the sky. This procedure disposes of the frost menace, the night temperatures being similar to those on the surrounding ordinary soil. This method is used extensively by the land owners in Sweden, but, as an application of 80 to 320 cubic yards per acre is required, its feasibility here is not so evident.

The fertilization also may play an important part in frost protection on peat soils. The injury has been less where fertilization is the most satisfactory and where, accordingly, the growth of crops has been most vigorous. The occurrence of the summer frosts on the peat lands, as has already been mentioned, is not due to the settling of cold air but to the rapid radiation of heat from the surface as compared with little radiation from below to the surface, the conductivity of the peat for heat being low; probably also the loss of heat through evaporation of water from the surface is a factor. Whether the protection afforded by the fertilizer is to be explained wholly by the lessening of radiation and evaporation due to the greater amount of foliage resulting from the fertilization has not

been definitely determined. As potash is the fertilizer that, when applied alone, usually produces the most marked benefit on peat soils it is also accompanied by the most marked benefit in warding off frost injury. To this fact is probably due the wide-spread belief that potash may serve on all kinds of soil as a protection from injury by frost.

The observations at Grand Rapids in 1914 fully confirm this view. On the night of September 4, a temperature of 24° F. was recorded on the bog. The potato vines suffered much injury, those on some of the plots being nearly all killed, whereas on others there was only slight injury. As there were over 50 plots and each fertilizer treatment appeared in duplicate on different parts of the bog there was ample opportunity to study the protection afforded by the different forms of fertilization. Potash alone had little effect upon the crops. The plots receiving potash salts alone were as badly injured as any, whereas those that received the most complete fertilization, and accordingly had made the most growth, showed the least injury.

Still another method of protection is the selection and development of resistant varieties of the different crops. As regards oats and potatoes, this plan has already much improved conditions for the peat-land farmers in those parts of Europe where the bogs are especially subject to summer frosts.

More promising than any other method is the one in which protection is secured by the farmers through the use of their peat soil for the production of forage crops. The grasses and clovers are highly resistant to frost, and when marketed in the form of dairy products or fat cattle reduce the potash requirement to a minimum and at the same time solve the problem of the high cost of transportation. Even in Europe where the large peat areas are more convenient to the supply of potash and to good markets they are being more and more largely devoted to the production of forage crops.

The question as to whether any particular tract of peat land in Minnesota, to confine my remarks strictly to my own State, can at present profitably be reclaimed for ordinary farming operations by proper drainage and fertilization, can not, in general, be definitely and reliably answered. In central Europe, Germany, and Austria, the officials of the peat land experiment stations are convinced that reclamation is economic in the case of all their peat lands. In Sweden there are 12,000,000 acres of peat land, compared with a total of less than 9,000,000 acres of land of all kinds at present under cultivation. Now, after nearly 30 years of investigational work by the Swedish Peat Land Society, the director of its experiment station considers that only the better class of peat lands, and only the parts of these convenient to transportation, can be profitably reclaimed at present. In England and Scotland it appears that the rental of the poor peat lands as game preserves is more profitable

than reclamation, whereas the better classes of peat lands— the fens —seem already to be fully reclaimed. In Norway, Finland, and Russia peat-land experiment stations have been established, but all are of comparatively recent date.

In Minnesota the farmers with small bogs are in general leaving these untouched, or using them as poor hay fields, or still poorer pastures. A few are trying to raise crops by the same methods employed on their ordinary soils, usually with very discouraging results. In the large areas of peat lands there are a considerable number of homesteaders who are working and waiting for some improvement in conditions. They are expending on their own crude experiments, without return in either crops or information of value, many times as much as would be required to support the needed peat experimental farms with the accompanying laboratory investigations.

Minnesota has the peat lands and we need no experiments to show that they are ill adapted to forestation. So the question becomes one of whether they are to remain waste lands—like the moors of Europe—or to be devoted to agriculture. That the University should immediately undertake the field experimental work is beyond all question, but for this money is needed. Our next legislature meets two years hence, and, like the peat-land homesteaders, we are wating and hoping.

DISCUSSION.

Mrs. Osborne (Ann Arbor, Mich.): I would like to ask Prof. Alway why it is that the Agricultural College men advocate subirrigation of peat lands, and the Department of Agriculture at Washington does not?

Prof. Alway: We speak of peat lands particularly. The Department of Agriculture in its researches has dealt with soils generally, and has devoted no special attention to peat lands. The physical condition of peat soil is of great importance. I may call attention to the fact that one of the first actions taken after the beginning of the war by the Austrian Land Commissioner was to recommend to farmers not to forget to roll their peat soils during the war.

B. Von Herff: The use of potash on peat lands is a valuable aid in the production of good crops. Concentrated potash salts can be bought at about $50 a ton, which is cheap if you consider one-half is plant food. The value of potash is illustrated by actual results obtained. An increase of corn has been obtained as high as 50 to 60 bushels to the acre. If only 10 bushels increase is obtained it gives 100 per cent return on the investment if 100 pounds is used to the acre. As regards special crops, such as alsike, it is impossible to get a crop without potash.

Prof. Alway: Whether potash can be used to advantage depends somewhat on conditions. Where high-priced crops are grown the expenditure required may be economic. But where, for example, oats are grown as a crop. 40 bushels to the acre at 30 cents per bushel produces $12. The purchase of 200 pounds of potash at a cost of $5.50 makes too heavy a load.

B. Von Herff: Why not cut it in two, and use, say, 100 pounds? The Germans, who use 200 pounds per year per acre, not only farm intensively, but their potash costs them less. We must regard local conditions.

The Chemical Composition of Some Minnesota Peat Soils*

By DeForest Hungerford

Contribution from the Division of Soils, Minnesota Agricultural Experimental Station.

In Minnesota peat soils are distributed rather generally over the State. Few, if any, of the counties are entirely free from deposits of one sort or another, but the most extensive areas are found in the region north, northwest, and northeast of Red Lake, including the northern part of Beltrami County, eastern Marshall County and parts of both eastern and western Roseau County. Somewhat smaller areas are found in St. Louis County and eastern Aitkin County.

Minnesota peat soils are of two general types—moss peat and grass peat. The former is commonly called "muskeg" and is usually, but not always, timbered. The latter is called "meadow" because it is always covered with grass even in timbered regions. The muskegs correspond in a general way to the "high bogs" or "high moors" of European countries, whereas the grass peat soils are similar to the "fens" of England and the "low moors" of continental Europe. They have been classified by Davis[1] as the muskeg of the northern part, generally covered by tamarack and spruce; the prairie types such as are found in the Red River Valley and in Marshall, Kittson, Pennington, and Red Lake Counties, and the marsh grass or meadow type, found in timbered regions and along streams. According to the classification of Tacke[2], based on the lime content, the peat soils are divided into three groups—the "high moors", containing 0.5 per cent. or less of lime; the "low moors", containing 2.5 per cent. or more of lime, and the intermediate group, in which the lime content lies between those limits.

Where the trees occur in Minnesota peat bogs, they usually consist of tamarack and spruce. Cedar (arbor vitae) and balsam fir are sometimes, but less freuently, found. Elm and black ash, which are reported by Davis[3] as growing on the peat soils of Michigan, occur but seldom, or not at all, on such soils in Minnesota. Locally the trees occur in dense thickets through which it is difficult for one to make his way, while in other places there are only a few scattered here and there. It is possible that in the areas with comparatively few trees fires have passed over and

*Read before the Duluth meeting, August, 1914.

was usually necessary to pulverize a part of the soil with a mortar and pestle in order to get it to pass through the sieve. If any sample contained large quantities of roots, sticks, or fresh blades of grass, these were removed before the sample was ground.

The volatile matter and ash were determined by igniting 5 grams of air-dry peat in a porcelain dish, first over a very low flame until volatile material ceased to be evolved, then in a Hoskins electric muffle to dull red heat until all carbonaceous matter was destroyed. It usually required about 45 minutes to insure complete incineration. The percentages of ash, volatile matter, and all other constituents were calculated on the basis of water-free soil.

For the determination of lime the ash was digested with con-destroyed them. Under such conditions Labrador tea and other shrubbery heath plants frequently come in, and the sphagnum moss, having a better chance because it is not shaded as by the trees, grows more luxuriantly.

Most of the samples analyzed were collected by the writer, the others being taken, according to his directions, by farmers living upon the land. Nearly all the samples were taken to the depth of 1 foot and each is a composite of several samples from different places in the bog. A section about a foot square was dug out with a spade, broken up, and mixed by hand on a piece of canvas, about 5 pounds being taken to another part of the field where another 5-pound sample was obtained in the same manner. This was repeated as often as was thought to be necessary—usually three times, sometimes more. A composite was then made by mixing the individual samples, and 10 to 15 pounds of the moist soil was placed in a sack and shipped by express to the experiment station.

To prepare the samples for analysis, they were dried in shallow pans in an oven at 70° to 75° C. for about a week, ground in a power mill, quartered, and passed through a 1-mm. sieve. It was usually necessary to pulverize a part of the soil with a mortar and pestle in order to get it to pass through the sieve. If any sample contained large quantities of roots, sticks, or fresh blades of grass, these were removed before the sample was ground.

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For the determination of lime the ash was digested with concentrated hydrochloric acid and 2 or 3 c.c. of concentrated nitric

acid. The silica was removed by filtration, and the solution made up to volume. Lime was determined in eight of the samples by the gravimetric method adopted by the Association of Official Agricultural Chemists[4], and in the other samples by the volumetric method, titrating with potassium permanganate.

Phosphorus was determined in 16 of the samples by the gravimetric method of the A. O. A. C.[4], a separate part of the solution prepared as above described being used. For the other samples a volumetric method was used, the ammonium phosphomolybdate precipitate being dissolved with a measured quantity of standard potassium hydroxide and the excess determined by titration against standard nitric acid.

Nitrogen was determined in a 2-gram portion by the ordinary Kjeldahl method and the acidity by the Hopkins method[5].

As peat soils are composed chiefly of vegetable matter, they have a much lower specific gravity than mineral soils, and this fact should be borne in mind when comparisons are being made of the plant-food content. The usual manner of expressing the chemical composition of soils is in per cent. of dry matter, but peat soils, being only one-eighth to one-seventh as heavy as mineral soils, contain much less plant food in an acre-foot than mineral soils having the same chemical composition. Field weight determinations in duplicate were made of the muskeg peat at Grand Rapids by cutting from the side of a pit a cube exactly 12 inches each way. The average weight shown by four such determinations of Grand Rapids water-free peat was 10.16 pounds per cubic foot, which is 221 tons per acre-foot.

The chemical composition of the peat samples is given in Tables 1 and 2. For the sake of convenience, and to show the difference in composition between the two types, the analysis of the muskeg peat and the grass peat are grouped separately. As the samples were taken from many different areas in widely separated localities, the data should give a general idea of the variations in composition of Minnesota peat soils.

Chemical Composition of Minnesota Peat Soils.

Table 1

Reference No. County.	Nearest Railroad Station.	Depth of Peat.	Ash, per cent.	Volatile Matter, per cent.	Total N, per cent.	P_2O_5 per cent.	K_2O per cent.	CaO per cent.
MUSKEG PEAT SOILS.								
1—St. Louis	Kimberly	27 in.	10.43	89.57	2.115	.395	.128	2.53
2—St. Louis	Skibo	6 ft.	10.53	89.47	1.634	.145	.165	2.41
3—St. Louis	Island	3½ to 5 ft.	16.41	83.59	2.181	.301	.130	1.66
4—St. Louis	Island	3½ to 5 ft.	14.86	85.14	2.250	.336	.113	2.45
5—St. Louis	Island	3½ to 5 ft.	12.22	87.78	2.07	.333	.086	.72
6—St. Louis	Meadowlands*	2 to 4½ ft.	10.97	89.03	1.58	.287	.087	.91
7—Beltrami	Kelliher	2 ft.	34.02	65.98	1.601	.274	.124	4.38
8—Beltrami	Kelliher	4 ft.	14.72	85.28	2.060	.329	.166	5.97
9—Itasca	Grand Rapids	6 ft.	7.83	92.17	....	...	...	.37
10—Itasca	Grand Rapids	2 ft.	12.03	87.97	....	...	...	.80
Average			14.40	85.60	1.93	.30	.125	2.22
GRASS PEAT.								
11—St. Louis	Kimberly	6 ft.	11.24	88.76	2.874	.450	.095	1.49
12—St. Louis	Wallace	9 ft.	14.10	85.90	2.274	.217	.082	1.74
13—Beltrami	Bemidji	4 ft.	10.40	89.60	2.860	.290	.079	2.52
14—Beltrami	Bemidji	5 ft.	6.78	93.22	2.820	.270	.105	2.38
15—Beltrami	Bemidji	....	9.97	90.03	2.790	.273	.139	2.93
16—Marshall	Middle River	2 ft.	10.48	89.56	2.693	.285	.104	2.80
17—Marshall	Middle River	....	29.07	70.93	....	.349	.094	7.06
18—Roseau	Greenbush	1 ft.	15.91	84.09	2.901	.369	.103	2.66
19—Kittson	Bronson	1¼ ft.	13.03	86.97	2.312	.332	.087	3.23
20—Pope	Lowry	2½ ft.	43.83	56.17	2.060	.302	.079	2.17
21—Dakota	Mendota	5 ft.	23.96	76.04	2.530	.378	.12	14.36
22—Meeker	Dassel	10 ft.	14.48	85.52	....	.295	.096	1.92
23—Renville	Hector	....	41.23	58.77	1.860	.318	.234	1.03
24—Nicholett	St. Peter	3½ ft.	43.08	56.92	....	.266	.326	3.10
25—Hennepin	St. Bonificius	3 ft.	17.73	82.27	2.755	.323	.071	2.17
26—Anoka	Stacy	....	28.27	71.68	2.765	.340	.085	2.20
27—Hubbard	Laporte	1 ft.	52.45	47.55	2.295	.557	.076	1.43
28—Polk	Beltrami**	½ to 2 ft.	38.07	61.93	....	...	...	3.95
Average			26.29	73.71	2.569	.331	.114	3.35

*Average of 6 Analyses, **Average of 5 Analyses.

The volatile matter, which in peat soils, consists chiefly of organic substances, is more than 50 per cent. in practically every case, and the ash content is the difference between this and 100 per cent. The largest amount of volatile matter, 93.22 per cent., is in one of the Bemidji soils. Although the individual soil containing the highest percentage of volatile matter is a grass peat, most the soils of the muskeg type contain the more. Only one of the samples of muskeg contains less than 80 per cent. of volatile matter in contrast with 8 of the 18 samples of grass peat.

When the nitrogen content is expressed on the percentage basis there appears to be a much larger amount present than is found in mineral soils. For example, the average nitrogen content of 73 Minnesota surface soils, as reported by Professor Synder[6] is 0.20 per cent., whereas the smallest amount reported in Table 1 is 1.58 per cent., which is nearly seven times greater. When one considers, however, that the weight of 1 acre-foot of mineral soil is 4,000,000 pounds, whereas an acre-foot of peat weighs only 500,000 pounds, or one-eighth as much, the apparent difference in the nitrogen content disappears. The average nitrogen content of 28 samples of peat soils is 10,949 pounds per acre-foot, the average of 72 samples of mineral soil is 8,000 pounds per acre-foot, and the average nitrogen content of 6 samples of mineral soil from the Red River Valley[7] is 16,000 pounds per acre-foot.

The phosphoric acid content of peat soil varies from 0.145 to 0.557 per cent, or 725 and 2,785 pounds per acre-foot. The average phosphoric acid content is 1,528 pounds per acre-foot, with 1,471 pounds as the average for the muskeg type and 1,654 as the average for the grass peat. Apparently, therefore, the grass peat is richer in phosphorus than the muskeg peat. Table 1 shows, however, that the difference is produced by four samples, two of which are grass peat and have an unusually high phosphoric acid content, whereas two samples of the muskeg have an unusually low content. With the exception of these four samples, the phosphoric acid content in the grass peat and in the muskeg is nearly uniform.

In regard to their content of potash, peat soils show a great similiarity, being uniformly deficient in that element. The average content of potash expressed as potassium oxide, (K_2O) is 556 pounds per acre-foot, and is practically the same in the two types—grass and muskeg peats. Two of the samples, numbers 23 and 24, contain considerably more than the others but even they are decidedly deficient.

The greatest variation is in the lime content, which European investigators consider an important indicator of agricultural character. In general the muskegs contain less lime than the grass peat soils, although there are several exceptions. For ex-

ample, numbers 7 and 8 contain 4.38 and 5.97 per cent. respectively, which exceeds all but three of the samples of grass peat. None of the grass peats contains less than 1 per cent. of lime, and only three contain less than 1.5 per cent., whereas only five of the muskeg peat soils contain more than 1.5 per cent. Three of the muskegs contain more than 2.5 per cent., which would place them in the grass peat class according to the German classification. They bear, however, the characteristic muskeg vegetation, sphagnum moss and white cedar, (Thuja occidentalis L.). Of the others, only those from Grand Rapids contain less than 0.5 per cent., which would place them in the "high moor" class, the remainder being in the intermediate group between 0.5 and 2.5 per cent. Nine of the eighteen samples of grass peat contain more than 2.5 per cent., and none is below the 0.5 per cent. limit.

These results show that in general, the muskegs of Minnesota do not conform exactly to the "high moors" of Europe as defined by the German investigators. It is probable, however, that a classification based upon the lime content would be more useful than one based upon the vegetation that happens to be growing upon the surface at the present time as it is well known that the surface vegetation varies from time to time because of temporary conditions, such as water supply and fires.

The acidity of 19 samples of peat soils was determined by the Hopkins method, the results of which are shown in Table 2. The lime content is included in the table to show the relation between this and the acidity. At present there is no method that is generally accepted for the quantitative determination of soil acidity. The results, however, show that at least a qualitative relationship exists between the lime content and the acidity. For example, those soils containing less than 1 per cent. of lime are decidedly acid, whereas those containing from 4 to 5 per cent. are practically neutral. Considerable disagreement between the lime content and the acidity is found in the intermediate soils. The method indicates which soils are strongly acid and which are neutral, but it is not a reliable indicator of the amount of lime required by the intermediate soils.

Table 2—Acidity of Peat Soils.

No.	CaO, per cent.	Acidity, per cent.	Lime required, pounds
1	2.53	0.085	1,696
2	1.41	0.082	1,632
3	1.66	0.052	1,040
5	0.72	1.556	31,120
6	0.91	1,320	26,400
7	4.38	Alk.	none
8	5.97	0.020	440
9	0.37	2.272	45,440
Grass Peat.			
11	1.49	0.089	1,780
12	1.74	0.047	936
13	2.52	0.059	1,184
14	2.38	0.040	792
16	2.80	0.044	880
18	2.66	0.041	808
19	3.23	0.043	848
25	2.17	0.065	1,304
27	1.43	0.039	784

Summary and Conclusions.

Twenty-eight samples of peat soil, 10 of which were from the muskeg type and 18 from the grass peat, were collected and analyzed. On most of the samples, determinations were made of volatile matter, ash, nitrogen, phosphoric acid, potash, and lime, and the acidity was determined on 18 samples.

The muskeg peat, in general, contained a higher percentage of volatile matter than the grass peat, this averaging 86.84 per cent. in the former and 73.71 per cent. in the latter.

The nitrogen content is higher in the grass than in the muskeg peats, the former containing an average of 1.874 per cent. and the latter 2.569 per cent.

The percentages of both phosphoric acid and potash are also somewhat higher in the grass than in the muskeg peats.

The greatest difference in composition between the muskeg and the grass peat is found in their lime content, although there is considerable variation in the amount present in different samples of both styles. The muskeg contains on the average 1.237 per cent. of lime, but different samples vary from 0.25 per cent. to 5.97 per cent. The grass peat contains 3.35 per cent as an average, and varies from 1.03 to 14.36 per cent.

The analysis indicate that Minnesota peat soils resemble, but do not agree exactly in composition with those of European countries.

[1] Davis, C. A., Peat and its origin: Mich. Geol. Sur. Rpt., 1906; pp. 108, 109.
[2] Tacke, Br. Untersuchung der Moorboden; in Untersuchung landwirtschaftlich und gewerblich wichtiger Stoffe, by J. Konig; 4th ed., pp. 115, 116, 123.
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[4] Haywood, J. K., et al., Official and provisional methods of analysis: U. S. Dept. Agr. Bu. of Chem. Bull. 107, pp. 15, 16.
[5] Hopkins, C. G., Soil fertility and permanent agriculture, p. 627.
[6] Snyder, Harry. Soil Investigations: Minn. Agr. Exp. Sta. Bull. 65, 1899; p. 69.
[7] Snyder, Harry, Op. cit., p. 27; and Soils: Minn. Agr. Exp. Sta. Bull. 30, 1893, p. 70.

The Peat Deposits of Minnesota

By E. K. Soper

Introduction—Nature and Scope of the Work.

The Minnesota Geological Survey, in coöperation with the United States Geological Survey and the Bureau of Mines, is investigating the Minnesota peat deposits, to ascertain their extent, distribution, and value, and the results of these studies will be published in bulletin form in the near future. The work is being done under the direction of Dr. Charles A. Davis, of the United States Bureau of Mines, and Dr. William H. Emmons, Director of the Minnesota Geological Survey. The actual field work was assigned to the writer, and work was started in June, 1914, and was continued throughout the summer of that year and all through the summer of 1915.

Method of Investigation.

One of the facts established early in the investigation is that Minnesota contains peat deposits far greater than had been generally supposed, and, in fact, more extensive than those of any other State in the Union. Because of the enormous areas of many of the peat deposits, it was soon realized that any detailed testing of bogs could only be done on certain selected areas which seem to be especially well situated for development. Such a detailed testing of some of our largest deposits would require years to complete, and in view of the constantly increasing demand in Minnesota for a report on the peat or muskeg lands of the state, and especially a demand for knowledge as to the agricultural possibilities of these areas, it was decided to examine as many localities as possible and to publish a report of a more general nature which would include descriptions of all of the larger muskeg and peat deposits in the State. Enough soundings were made to determine whether the land should be classified as easily

reclaimable for agriculture or as better adapted to the manufacture of peat fuel or other peat products. During the two seasons of field work every county in Minnesota was visited and detailed examinations were made in every county which contained peat. In addition to the data thus collected, a large amount of valuable information, including thousands of soundings, has been contributed by the engineers engaged in the various State projects for draining the great swamps of northern Minnesota.

This brief paper presents only the more important results of the preliminary survey of the Minnesota peat deposits.

Distribution.

There is peat in nearly every county in Minnesota, but by far the largest, deepest, and most important peat deposits occur in the "muskeg" swamps, and open bogs and marshes of the northern part of the State. There are only three areas in the State which are without peat; one in the "driftless area" in the extreme southeastern corner of the State; a second in the extreme southwest corner; and the third along the western border, adjoining North and South Dakota. This last region lies chiefly within the Red River Valley, which is entirely treeless, and the floor of which consists of fine silt and clay to a considerable depth.

The peat deposits of Minnesota fall into three more or less distinct groups, as follows: (1) Those in the northern part of the State, the so-called "muskeg swamps," which occur chiefly in Beltrami, Koochiching, St. Louis, Itasca, Rosseau, Aitkin, Crow Wing, Cass, and Clearwater Counties; (2) those in the central part of the State, the largest and best of which are in Anoka, Ramsey, Wright, Hennepin, Stearns, Sherburne, Isanti, Washington, Chisago, Mille Lacs, and Douglas Counties; and (3) those in southern Minnesota, chiefly in Blue Earth, Nicollet, Le Sueur, Rice, Scott, Carver, Dakota, Steele, Freeborn and Waseca Counties.

Classification of Minnesota Peat Bogs.

The classification of the Minnesota peat deposits into the three groups just mentioned is based on more than geographic distribution, for the peat in the northern, central, and southern parts of the State shows distinct differences as to origin, character, and composition, and the deposits in each group occur in an environment more or less characteristic for that region. These three groups will be discussed separately.

In general the peat deposits may be classified into the following types, based on the method of origin:

1. Deposits that represent filled lakes or ponds.
2. Deposits that represent built-up moist depressions or flat, undrained areas.

3. Deposits that represent combinations of types 1 and 2, and consist of lake or pond peat in the lower part and sphagnum peat above.

Each of the above main types may be subdivided into two or more subtypes, based upon the character of the old surface, the character of the original vegetation, the composition of the peat, etc.

Northern Minnesota.

The peat in northern Minnesota occurs chiefly in the "muskeg swamps" so characteristic of northern Minnesota, Wisconsin, and Michigan and parts of Manitoba and Ontario. The peat in these muskegs is formed chiefly of sphagnum or peat moss, and some of the largest bogs in the region, embracing hundreds of square miles, are built up almost entirely of successive layers of this moss. Scattered over these immense swamps of sphagnum peat are smaller areas where the peat is much deeper and of a different character. These deep parts of the bogs represent filled lakes, and the peat deposits show a different origin and structure from the prevailing sphagnum type of the north. In these filled lakes the peat is formed of sphagnum only in the upper part of the deposit and down as far as the old water level of the original lake. Below that depth, the peat consists of the remains of sedges, grasses, rushes, and pond weeds so characteristic of all deposits that represent filled lakes.

The sphagnum peat of northern Minnesota is by far the most important as regards quantity as well as quality, and it is probable that at least three-fourths of the area covered by peat in this region was originally a flat, undrained land area on which the peat has accumulated by the building up of successive layers of sphagnum moss. These great swamps mostly occupy parts of the old bed of the ancient Lake Agassiz, which covered the region in glacial times and which has gradually dried up until today it has receded northward to Lake Winnipeg in Manitoba, which is a remnant of this former immense body of fresh water.

With the gradual disappearance of the great water area, new land became exposed. This land, as would be expected, was without adequate drainage. The lowest parts of the old lake bed continued to be covered with water after the higher areas were dry, and as the lake receded northward the upper, or most northern, part of the area was the last to be drained. The depressions and irregularities in the newly exposed surface became the sites of small shallow lakes and ponds around which there quickly sprang up a type of vegetation very similar to, if not identical with, that which now fringes such lakes on the flat marshy lands of this region. The areas around the shallow lakes and ponds were subject to inundation during the spring months, and al-

though they were flooded only at certain intervals, they were kept constantly wet. In this way conditions were brought about favorable to the rapid growth of peat-forming plants. As these plants died, their remains were prevented from decay by the excessive moisture of the region. Thus, large peat beds rapidly accumulated over much of this region, and, in fact, are still accumulating in nearly every muskeg swamp in northern Minnesota.

Every peat bog in Minnesota is of post-glacial age; and it is a noteworthy fact that all of the peat deposits in the State occur in glaciated areas, where the subsoil consists of glacial drift, —either land-laid or water-laid. In the driftless areas of the State there is no peat. It should be mentioned in this connection that at several localities in Minnesota, as in Michigan and other regions in the northern United States, deposits of a peaty nature have been found between two sheets of drift. These represent peat beds of glacial age which accumulated during intervals between successive ice invasions. In no case, however, in Minnesota were such deposits found to be of any commercial importance, and the material in each deposit noted consisted of a peaty turf mixed with a large proportion of mineral soil.

It is not yet possible to give more than an approximation of the area of peat land in northern Minnesota. The area of swamp land, as classified by Federal and State surveys, is fairly well known, but much of this area is covered by only a shallow layer of peat, whereas some of it has no peat whatever and has been drained and converted into good farm land. The area of swamp land in the northern part of Minnesota is something over 7,000 square miles. This estimate includes a few small lakes and ponds, but none of the larger lakes. It is safe to estimate that originally three-fourths of this area was covered by peat at least 3 feet thick. Large areas in Baltrami and Roseau Counties have been burned, and much of the peat destroyed; and other areas have been drained, and the peat has dried and shrunk in thickness. It is estimated that there are approximately 4,000 square miles of workable peat deposits in northern Minnesota over which the peat will average at least 7 feet thick. The depth will vary from a few feet up to 35 feet in one or two bogs, which represent deep lakes which have become completely filled. There are hundreds of square miles in Baltrami, Koochiching, Itasca, and St. Louis Counties over which the peat will average at least 12 feet thick. On the assumption that there are about 200 tons of peat fuel available per acre for each foot of depth, the total available fuel in these 4,000 square miles of peat deposits will be 3,584,000,000 tons. This fuel when manufactured into machine-peat bricks and sold at $3 a ton would have a total value of $10,752,000,000.

It has been estimated by Dr. Charles A. Davis that the total area of workable peat deposits in the United States is approximately 11,188 square miles. If the estimate of 4,000 square miles for Minnesota is approximately correct, it shows that nearly one-third of all the workable peat in this country occurs in Minnesota.

The character and composition of the peat in northern Minnesota is remarkably uniform when the immense size of the deposits is considered. As already stated, sphagnum moss forms by far the greatest part of the peat, and sedges, heath shrubs, and grasses constitute nine-tenths of the remainder. Pond weeds, rushes, etc., are found in many bogs in subordinate quantity; and in a few of the deeper bogs, which are filled lakes, these plants form a large proportion of the lower half of the deposit. The peat is usually dark brown in color, rather fibrous, especially through the top 4 or 5 feet, and much of it is very fibrous and mossy on top. It is usually soft, but not mushy, although the lower parts of many of the deeper deposits are rather fluid, and a few, at great depth, are too fluid to make it possible to obtain a core in the sampling instrument. The composition and character of the material change all of the deeper deposits at a level that represents the former water surface in the original lake in which the peat accumulated. Above this old water level the deposit consists of brown fibrous mossy peat; below that horizon, of softer peat of a lighter shade of brown and often greenish or yellowish and consisting chiefly of the remains of sedges and grasses.

The composition and the fuel value of these muskeg peats of the north are also uniform. The following analyses are typical of these deposits. Typical analyses of muskeg peat samples of northern Minnesota:

Proximate.

	As Received	Dry Coal	Calculated to Moisture and Ash Free
Moisture	12.48	....	....
Volatile combustible	58.32	66.64	72.89
Ash	7.50	8.57	....
Fixed carbon	21.70	24.79	27.11

Ultimate.

	As Received	Dry Coal	Calculated to Moisture and Ash Free
Hydrogen	6.02	5.29	5.79
Nitrogen	2.08	2.38	2.60
Carbon	46.31	52.91	57.87
Oxygen	37.86	30.59	33.46
Sulphur	.23	.26	.28
Ash	7.50	8.57	....
Total Heating Value	8007	9149	10006

Proximate.			
Moisture	11.03	....	....
Volatile combustible	59.20	66.54	72.78
Ash	7.63	8.58	....
Fixed carbon	22.14	24.88	27.21
Ultimate.			
Hydrogen	5.97	5.33	5.84
Nitrogen	2.39	2.69	2.94
Carbon	46.63	52.41	57.33
Oxygen	37.15	30.73	33.61
Sulphur	.23	.26	.28
Ash	7.63	8.58	....
Total Heating Value	8057	9056	9906

The vegetation now growing upon the peat bogs of northern Minnesota is almost identical with that found in the muskegs of northern Michigan and Wisconsin and eastern Canada. In fact the vegetation on all of the northern muskegs is essentially the same. It consists chiefly of tamarack and black spruce trees, or associations of both; the heath shrubs, including Labrador tea, swamp laurel, andromeda, and chamaedaphne; cranberry and blueberry, and sphagnum moss. Some of the swamps are forested with a heavy growth of white cedar, and frequently cedars are associated with either spruce or tamarack. These cedar swamps however, are not typical muskegs and the peat in them is usually more shallow, contains more woody fiber, and little or no sphagnum. In the center of some of the large muskegs there are open bogs upon which no trees of any kind occur. These are covered with a dense growth of heath shrubs and a thick layer of sphagnum. In some cases where the open bogs are very wet, sedges and cattails are prominent.

A very different type of bog found in the north is the open sedge-grass marsh or meadow. This type is very frequently met with in the southern part of the northern province, especially in Cass, Hubbard, Clearwater, Aitkin, Crow Wing, Becker, and Otter Tail Counties. Most of these peat marshes are small and represent filled lakes or ponds. The peat is composed chiefly of sedges, grasses, rushes, cattails, and frequently pond weeds and some mosses are present. There is never sphagnum. The vegetation on these deposits consists of sedges, grasses, cattails rushes, reeds, and subordinately of small herbaceous plants, and occasionally a few scattered willows and other shrubs. The peat is of excellent quality, and much of it is deep. There are no analyses available at the time of writing this paper, so a comparison of the chemical composition and fuel value with that of the muskeg peat can not yet be made. Analyses made in other

States, however, show this type of peat to be equal to, if not better than, the sphagnum peat in fuel value and low ash content.

Central Minnesota.

The peat deposits of central Minnesota are in part identical in origin and history with those just described. However, sphagnum moss does not grow, except rarely in isolated places, south of an east-west line drawn approximately through the cities of Minneapolis and St. Paul. Hence north of this latitude, the peat is of the same general type as that of northern Minnesota; and south of it the peat is of an entirely different type; whereas along a belt 25 to 30 miles wide, near the dividing line, there are numerous deposits of each type, and some deposits that represent combinations of both. The peat bogs of central Minnesota are not nearly as large as those of the north, but are much larger than those south of this region. The best and largest deposits lie in Anoka, Ramsey, Wright, Hennepin, Stearns, Sherburne, Isanti, Washington, Chisago, Mille Lacs, and Douglas Counties.

The tamarack swamps or muskegs of the central part of the State are numerous, but are very small—usually containing less than 100 acres. On the other hand, there are some very extensive open sedge-grass bogs, called "wire-grass" marshes, scattered throughout central Minnesota. One of the largest of these occurs only about twelve miles north of Minneapolis and St. Paul, in Anoka County, and contains good fuel peat with an average depth of 6 to 7 feet over many thousands of acres.

Southern Minnesota.

All of the peat of southern Minnesota is found in open, treeless meadows or marshes, and is composed chiefly of sedges, grasses, cattails, rushes, and other plants that are common to such an environment. The peat beds represent in part filled lakes and ponds, and partly built-up deposits on low, undrained areas. They occupy the low land around the shores of lakes, or along river valleys, or merely low, undrained depressions in the drift. Most of them are very small in area and shallow in depth compared with the peat bogs of the north, but nevertheless numerous deposits of commercial value exist, especially in Blue Earth, Nicollet, LeSeuer, Rice, Scott, Carver, Dakota, and Freeborn Counties

Conclusion.

The quality of the Minnesota peat, especially that from the northern portion of the State, compares favorably with that from any part of the world as to its fuel value. Some of the European peat is more decomposed and contains less ash and hence contains more heat units, pound for pound. On the other hand, a large part of the peat used commercially in European countries,

especially that in Sweden, Denmark, Germany, Russia, and Switzerland, is formed from the same plants in the same way as that found in Minnesota, and is almost identical with it in its composition and physical properties. As to the total quantity of peat in the State, it is not yet possible to give even approximate figures as to tonnage, etc. The estimate given earlier in this paper of the quantity of peat was for northern Minnesota only. However, the deposits in the north are so vastly greater than those in central and southern Minnesota that the total estimate for the entire State will probably not show any notable increase.

The most profitable commercial use that can be made of the peat in Minnesota is a question of great importance at the present time. It seems probable that the manufacture of power in peat-producer gas plants will soon be attempted and there seems to be an unusual opportunity in Minnesota for success in that field, especially in the iron-mining districts. Such power has been successfully produced in a number of large plants in Europe and there seems to be no reason why their success can not be duplicated here. Prof. Peter Christianson, of the Minnesota School of Mines, is continuing his experiments on the adaptability of Minnesota peat for use in the smelting of the iron ores of the State. These experiments were described by Professor Christianson before the American Peat Society last year at the Duluth meeting.

The manufacture of machine peat for domestic and other fuel offers a most attractive field in Minnesota. The presence of such large amounts of peat of excellent quality, situated, as many of them are, immediately adjoining railroad tracks, and near large and thriving towns, makes it certain that this industry will develop in a comparatively short time.

The possibility of using for agriculture the large tracts of shallow peat land that embrace hundreds of square miles in northern and northwestern Minnesota, is of the greatest importance. The industrial future of several entire counties in northern Minnesota depends in a large measure upon the uses that can be made of the peat deposits there. The State farm school is constantly carrying on experiments to determine the agricultural value of Minnesota peat lands, and Dr. F. J. Alway, who is in charge of this work, has already given you an idea of what has been done.

For several years past the State has been at work upon the problem of draining these swamps, and already over 1,000 miles of large ditches have been constructed. With the digging of the ditches comes the construction of roads and the influx of settlers. Thus the last real wilderness of the northwest is rapidly disappearing, and the very peat which once rendered the region practically impenetrable is proving to be one of its greatest assets.

OUR MARSHES

By Carl Kleinstueck*

It is only a comparatively few years ago that a man in this great country of ours did not dare to mention the subject of peat and peat utilization to any one, outside of his own family, without running the risk of being looked at askance and being considered mildly unbalanced. Only a few scientists had studied our immense peat deposits and their possibilities, but the public at large was not aware even of the presence of peat bogs on this continent. Fuel, in the earlier days, let us say about 1880 A. D., was so ridiculously cheap that nobody could sense any reason whatever in bothering over the country's future fuel supply.

Wood of every sort and description—certain kinds of which are now rated at so many hundreds of dollars per thousand feet—was offered at one's front door in Michigan, by the sleighload at 5 cents per cord. Now one pays approximately twelve times as much for the same amount of wood. In other words, the amount of stovewood purchasable in Michigan in 1880 for 75 cents costs approximately $10 now; and the 75-cent cord wood of the eighties consisted of the finest hardwood timber imaginable, whereas today one gets slabs and retired dry goods boxes for one's money.

Coal—the best anthracite—could be had at $5 per ton at any time, so what was the use of worrying about fuel, especially in face of the fact that scientists had told us again and again that the world's coal supply could never be exhausted?

Besides, the woods were full of trees and they were growing all the time—nobody could prevent trees from growing! so—why bother about the future supply of fuel?

That was the feeling in the eighties, barely a third of a century ago, and at that time it did not seem hardly necessary to make provision for future fuel. However, the writer, in the happy days of his bachelorhood spent in various countries, had been made acquainted with the inevitable necessity of paying fuel bills when due, so that he had become much interested in the fuel question itself.

If a man has to consume at least 20 tons of coal per winter in order to keep himself and family from freezing, I think he is entitled to an opinion of his own regarding the advisability of procuring a less expensive material for keeping warm, and I am proud to say that, as the years have passed, and the fuel prices have advanced by hops, skips and bounds, my fuel views have become more and more settled, and I have determined to study the situation thor-

*Read at the Detroit meeting, September, 1915.

oughly and to help the country and, incidentally, myself to find a substitute for our ever more expensive fuel.

Nor was your servant the only person in the land similiarly inclined. Here and there voices were becoming loud, bewailing the high cost of living in general and the ever increasing price of fuel in particular. However, it was not until the big coal strike of 1902 that really effective steps were taken to find substitutes for coal and wood.

True, scientists and a few isolated "cranks," as they were called at the time, had for years investigated and experimented with peat, but real public interest in the astounding possibilities of our deposits was not aroused until the time stated. The big coal strike of 1902 brought us forcibly to the realization of the fact that, no matter how inexhaustible the coal supply of the world, without the miners to bring it to the surface, we easily could freeze to death in spite of it.

That all happened in the past and bears no other relation to the subject under consideration than to bring my hearers to the point in peat history, where the value of our bogs slowly, very slowly, began to be realized and appreciated and from which peat history in the United States really took its start.

Up to this time by far the largest number of bogs were considered practically worthless, and any man looking favorably at them and perhaps making purchases of a few hundred acres of good peatlands here and there was looked upon as a dreamy visionary.

That all has materially changed within the past ten or twelve years; boglands in Michigan, which could be had at $10 to $25 per acre in 1901 or 1902, readily sell at ten times that price now.

In marshes where barely ten years ago nothing but the wildest kind of jungle life existed, huge drainage machines have restricted the water to proper channels and instead of a "howling wilderness" we find in many of our bogs smiling fields of celery, peppermint, and onions.

And those lands are taken up and put to cultivation almost as fast as proper drainage gives access to them.

Many of the crops produced are enormous, yields of onions as high as 800 bushels and over not being exceptional by any means.

And what is true in this respect in Michigan pertains in similar measure to other States of the Union.

The magnificent crops of garden truck produced in the muck near Duluth, Minn., will not easily be forgotten by the delegates of our 1914 convention.

Not more than 14 years ago it was my good fortune to find myself in the heart of the Florida Everglades, the wildest of all wild countries I had visited up to that time. For days not the faintest sign of any man's actions could be detected anywhere.

Camping one night on one of the numerous islands scattered over this vast stretch of marshland, Billy Tigertail, Seminole chief, appeared on the scene and, evidently astonished at the presence of a white man in his up-to-then unconquered realm, assured me that only one European, an Englishman, had ever penetrated the "Glades" so far before.

Look at the Everglades today! They are drained and where only a few years ago, alligators, egrettes, and limpkins bellowed, splashed, squawked, and waded through an almost undisturbed life, we find truck farms along the banks of navigable canals, and long vistas of celery and onion fields—the whole scenery completely transformed as if by magic.

Wherever insatiable man enters the marshes the wilderness disappears and thousands upon thousands of acres of formerly comparatively unproductive and correspondingly worthless swampy wastes are made subservient to our wishes, and forced to yield their treasurers hidden from us for untold eons.

From the standpoint of the lover of nature, this, indisputably, portends a loss incalculable and never to be condoned.

But to the economist the subjugation of our dismal swamps signifies a gain in the direction of increased national wealth, which cannot possibly be overestimated.

Not far from here is a swamp of approximately 30,000 acres.

Some 40 or 50 years ago fire practically consumed all the timber on that land, which up to that time had furnished the only revenue man had been able to wrest from that vast territory.

With the wood all gone Gun Marsh practically ceased to yield any revenue, and 30,000 acres of the richest soil imaginable were lying idle for over a quarter of a century.

In 1880 passing Gun Marsh I turned to my companion, one of the oldest settlers of that district, inquiring of him how much that kind of land was considered worth in that part of the world.

"That land?" he said, pointing disgustedly with his thumb over his shoulder in the direction of Gun Marsh, "That thar land ain't worth nothing!"

"But," I continued, "suppose I should like to own that marsh, at how much do you think I could purchase it?"

"Oh," he shouted, "you kin get the hull d—— shooting match for 75 cents an acre!"

That very same land today sells at $100 to $200 an acre!

It would be presumptuous to claim that the few peat men of the country were alone responsible for this marked change of conditions in our marshes, but no one, familiar with pertaining facts, will deny our claim of being among the most active of marsh pioneers, and I think we have every reason to be proud of our accomplishments along that line.

In many instances the peat man has blazed the way into formerly almost inaccessible morrasses, and has drained and subdued them, and the truck farmer has reaped a rich harvest on the soil, which was primarily approached for the purpose of converting it into fuel.

So far, it would seem as if the Dutchman had the better of the bargain: he takes comparatively few chances and can nevertheless almost bet on a rich and bountiful crop, whilst we peaters on the other side have not yet emanated from the experimental stage of fuel making.

Be that as it may, there can not be a moment's doubt that the profitable production of a cheap peat fuel in this country is only a matter of time; no matter if the world's coal supply would hold out another thousand years or more, the annually increasing price of coal simply must force the country sooner or later to use our immense deposits of excellent peat as substitute fuel.

Perhaps none of the handful of faithful peat men that originally conceived the idea of a propaganda for the utilization of our peat bogs, and have stood by it through adversity and often bitter disappointments, will see the dawn of that day, but if our hour of final departure comes we can go with the honest conviction that we were the first to open the country's eyes to the incalculable value of our bogs and that we have often under great hardships and amid dangers paved the way for a younger generation into our formerly practically trackless, pathless swamps. LET THEM FOLLOW!

DISCUSSION.

Prof. Davis commented on the address of Mr. Kleinstueck, referring to his excellent work in advancing the interests of the Society, and pointing out the very great importance to the country of the work that had been inaugurated in the reclamation of marsh lands in various districts, for which the Society could reasonably claim a large share of credit. What was wanted, he stated, was careful and concerted effort along such lines as had been laid down by the Society, and the avoidance of foolish promotion schemes by men who were ignorant of peat, and saw in the peat industries merely another field of exploitation for the benefit of their own pockets, and whose operations in the past had done great harm.

Mr. Kleinstueck: The promoters have stolen our good name. One man whom I know attempted to press the water out of peat with a machine which worked well perhaps for making pills, but he succeeded in pressing more sweat out of himself than water of out the peat.

The Peat Soils in Michigan and their Value in Agriculture

By Prof. A. J. Patten

No State had suffered more from false statements than Michigan. Early explorers declared the State favorable only to the wolf, the Indian, and the ague. One of the earlier reports stated it to be so bad that not more than one acre in 100, if more than one out of 1,000, was fit for cultivation. These people would be surprised to come back today and view its beauty and fertility.

The State still suffers from the misrepresentations of real estate firms trying to palm off worthless lands on investors. A firm that has its home office outside the State has recently sold to widows and orphans swamp lands in northern Michigan, underlaid with sand and formerly a lake bed. The peat on these lands is extremely acid. Analyses showed that 8260 lbs. of lime per acre would be required, and would cost more than the land is worth. Taking into consideration the character of the underlying strata, and with our present knowledge of how to handle it, such land is at the present time absolutely worthless. The analyses published by this firm represent good clay upland soil, and have no more resemblance to muck soil than black to white. There ought to be some machinery of the State government by which the issuing of advertising matter of such character could be prevented, but there seems to be no way of getting hold of people operating outside of the State.

It has been estimated that there are in Michigan 4,400,000 acres of swamp lands reclaimable for cultivation, a little less than one-eight of the total. I consider this too large. No data are available as to the peat lands now cultivated, but they certainly represent a very small percentage of the total. No soil surveys have been made. The State experiment station, owing to insufficiency of funds at its disposal, has at present no means of carrying on extensive field investigations. Its work hitherto has been almost entirely confined to laboratory and greenhouse experiments.

Recently through county and township drainage projects large areas have been reclaimed, and there are also many successful private projects, for example, that of the Washoe Sugar Co., in Saginaw County, where about 10,000 acres have been reclaimed by pumping, on which most general farm crops, as well as peppermint and onions are successfully grown. Also the two large farms of Mr. Todd of Kalamazoo in Van Buren County. A large area is now being re-

claimed in the Chandler Marsh near our agricultural college, on which the peat soil is of excellent character for agricultural use.

The most extensive crop grown so far has been peppermint. Eighty-eight per cent of the total production of the United States, and about three-fifths of the world's supply is grown in Michigan. In 1914 6292 acres was devoted to this crop, producing 120,182 lbs. of oil, worth $192,801. Besides the production of oil, peppermint straw affords large quantities of excellent bedding for horses.

There are at least four ways in which peat is of special value to agriculturists,—as follows: (1.) As soil for growing crops; (2.) as stable litter; (3.) as a direct fertilizer on light sandy lands; and (4.) as a fertilizer filler.

Features that are particularly to be taken into account as regards the utility of peat for cultivation—are as follows:

(1) The physical characteristics of the peat and underlying soils; (2) their chemical characteristics, and (3) possibilities of drainage.

Black muck soils of 3 or 4 feet deep give the best satisfafction, and the underlying strata are a large factor in the value of the soil. It is common in Michigan to find peat beds underlaid with marl, and these give the best results. The peat in such bogs is almost never acid, as the underlying marl corrects the acidity. Bogs underlaid with sand are practically always acid, and those underlaid with clay are also liable to show considerable acidity of the peat.

Much experimenting is still required, especially on bogs underlaid with sand to bring them to a good state of cultivation and fertility. It is a question whether it is advisable with our present knowledge to attempt to grow the usual crops on bogs of this type. They might, however, be profitably used to grow blueberries, which do well on an acid soil. A large industry along this line might be perhaps built up in Michigan. In Maine it is a highly profitable industry. In one county in that State about 75,000 busehls is put into cans every year, distributing nearly $200,000 among the poorer classes of people.

As an example of what may be accomplished on small holdings, there may be cited the results obtained from 6¼ acres of the Prison Farm at Jackson, Mich., in 1913. One hundred and fifty loads of manure was used on the land, and 275 pounds of complete fertilizer. The returns were: 2,300 crates of onions, 200 crates of beets, 2,500 crates of carrots, 2,500 crates of parsnips—7,500 crates in all, yielding $600 to $700 per acre. There are many opportunities to use small peat areas profitably for growing truck crops. The principal reason for growing grain crops is often to get the straw. Farmers might in many instances give up grain growing and get peat litter at their door, and thus increase the value of their manure.

DISCUSSION.

Mr. Kleinstueck: An educational propaganda on the value of peat to the farmer is very desirable. Peat litter is one of the best absorbents, and its use would save the liquid manure now generally entirely wasted in this country, but carefully saved in Europe, where more intensive farming prevails. A farmer in this country will pay $10 a ton for straw, when he has a much better bedding in the peat moss right on his farm, one might say at the door of his stable. Besides its other advantages peat litter is excellent for the feet of horses and cattle.

Mr. Bergh: In northern Minnesota we are impressing upon the farmers the importance of dairying. They have an abundance of pasture in summer, but during our long winters require all their straw for feeding. Among other experiments carried on, we are including the preparation of peat for litter, similar to the sample shown here today. We send men into the peat bog in the fall, and pile up the peat in ricks and leave it until the next fall. Then we put it through an ensilage cutter, producing the shredded product exhibited. By using it for litter the farmer can practically double his manure output, and at the same time save his straw for feed.

Mr. Todd: Will the use of fertilizers reduce the acidity of muck soils underlaid by sand?

Dr. Patten: It may be doubted whether it would remove it entirely.

Prof. Davis: The action of tillage resulting in successive exposure of the peat to the air often does more to destroy acidity than anything else.

Mr. Wiedmer: We find that deep plowing helps us.

Dr. McWilliam: The explanations of Prof. Patten with regard to the effect of the soil strata underlying bogs has cleared up some difficulties for me. I have noticed the difference of the flora in swamps, e. g., large quantities of cedar may be found in some, and none at all in others.

Prof. Patten: The difference in flora is largely controlled by the chemical composition of the soil.

Prof. Robinson: Dr. Dachnowski has taken up the matter quite fully in his publications. Plant toxins may be developed under certain conditions which are unfavorable to the growth of some plants but do not affect others. High and low moors are discussed by Dr. Bersch in the Zeitschrift fur Moorkultur, and he distinguishes them on botanical grounds. The growth may be said to be in three stages, the acid formation being found on high moors.

Prof. Davis: The theory would not appear altogether to fit the facts. The main factor controlling the distribution of plants is the relation between the top of the ground water and the sur-

face. Where elms will grow on a bog, the ground-water table will be lower than where cedars thrive. On high moors trees sometimes develop, the ground-water level from some cause rises, and the trees are killed off, and the moor again produces sphagnum.

Mr. Wiedmer: In our bog of 10,000 acres, which was drained in 1882 below the peat level, there was never any tree growth before drainage to the knowledge of the oldest inhabitants. Now numerous young cottonwoods grow up, but they die in about six months.

DISCUSSION AT THE DETROIT MEETING REGARDING A FEDERAL PEAT EXPERIMENTAL STATION

By Society Members

Mr. Kleinstueck: Before the Convention closes we should put on record a demand for the establishment by the Federal Government of a practical peat experimental station. Realize how many millions of acres of the best lands are lying idle from which the United States draws no revenue. In Michigan during the past few years we have reclaimed 25,000 acres on Gun Marsh, which was perfectly worthless before, and now much of it is producing valuable crops. Mr. Todd, who is here from Kalamazoo, is conducting a very large farm on which enormous crops are raised—as many as 1,000 bushels of onions to the acre. The revenue derived from the land to be reclaimed will in a very few years pay for a hundred experimental stations.

B. Von Herff: I fear that conflict between State and United States experiment stations might present some difficulties. I would like to ask Mr. Todd how much potash he uses?

Mr. Todd: We have 3,500 acres under cultivation near Kalamazoo and use potash very largely. The amounts used vary according to crop requirements. One thousand bushel of onions to the acre will consume 200 pounds of murite of potash.

Prof. Alway: What initial dressing was used?

Mr. Todd: The same as for other years.

Prof. Davis: With regard to establishment of a Federal experiment station, it is practically impossible for the United States to take up the peat question satisfactorily at any one station. Peats differ, and a station would be required in practically every State where Peat occurs. We have with us today representatives of several State experiment stations. They are doing good work, and doing it as fast as they can, and I think we may safely leave this matter of experimentation to the States directly interested. We have already secured excellent arrangements for cooperation with the Bureau of Plant Industry, and my impression is that it would not be wise at the present time to ask for more than we are getting. The extent of the Peat bogs in certain States makes the development of peat lands a matter of great local interest. Bavaria could be set down and lost in the Minnesota peat bogs; 7,000,000 acres in Michigan is rated as swamp lands.

New Value in Muck Lands

By Robert Ranson, St. Augustine, Fla.

Inoculating the Soil.

Under date of November 16, 1915, The Times-Union published a paper by me in reference to the above interesting subject, which is here reproduced with some additional information from England as to the progress of these experiments. The information is of peculiar interest at this time as showing a new value in muck soils in the various drained areas of the State.

I am in possession of a letter sent me from Professor Bottomly through a third party, as follows:

"No time has been lost in forming a national committee for the purpose of bringing into general use Prof. W. B. Bottomly's discovery of HUMOGEN, the new fertilizer, which in an experimental stage is understood to have produced results greatly in excess of those produced by ordinary manures. The British Board of Agriculture, which was lukewarm in its attitude toward this discovery for a long time, has now changed its attitude and ordered futher experiments at once. Meanwhile 10 tons of bacterized peat is being turned out weekly from an experimental factory and this production should show results of great importance by next season."

A clipping from a London paper, dated October 25, 1915, states that in July, 1914, Professor Bottomley was approached by German agriculturalists asking for samples of his bacteria for the German Board of Agriculture, but they were refused.

Although during the past 20 years such wonderful discoveries have been made by science in medicine, surgery, and the mechanical arts, it is interesting to note parallel advances rapidly progressing in the cultivation and improvement of soils; and as the veil dividing the known from the unknown is being gradually lifted we stand amazed at the possibilities spread out before our gaze in agriculture.

Origin of Agricultural Chemistry.

The first great step from the old to the new dates back to the forties, when Lawes and others introduced chemistry to the notice of the farmer, and chemical manures of certain fixed proportions took the place of older methods, thereby enormously increasing the yield of food and forage crops.

We have now enlisted the services of the bacteriologists, who, with their improved microscopes, have uncovered vast empires of bacteria hitherto unknown. As the ordinary bacterium

reproduces itself by division every half hour, one single specimen would in the course of a day and a night become the ancestor of 280,000,000,000.

Thus, although we owe the chemists a great and lasting debt, it now appears that still greater benefits may come from the bacteriologists.

Useful Services of Bacteria.

Friendly bacteria can be made to fight the battles of the gardener and husbandman.

As is well known to medical science, in the treatment of the human body, bacteria often conquer diseases by introducing something that in itself is a minor disease, so also is it possible by Nature's help to introduce bacteria to cure the defects and deficiencies of the soil.

For years we have observed certain phenomena in connection with plant growth without either understanding their real cause or effect.

For example, we have noted on the roots of leguminous and other plants small nodules or tubercles and spoken of them as a disease, which in reality they are. The bacteriologist, however, has shown us that, though there is a diseased condition of the roots, in these tubercles exist myriads of bacteria, which, while looking to the plant for food and shelter, are liberally paying for their accommodation by furnishing to the plant itself the nitrogen so necessary to its healthy growth, and thus in most cases more than compensating the plant for the disease they cause.

Thus the problem of uniformly successful growth is theoretically capable of solution by introducing into the soil the right kind of bacteria to aid the particular crops we desire to grow.

It is difficult to conceive of any more fascinating employment than to be able to direct intelligently the vast operations of millions of willing slaves in the shape of bacteria towards improved production of the necessaries and luxuries of life, and we seem to realize as never before the complete fulfillment of God's promise to man in the first book of the Bible that he shall have dominion over every living thing that moves upon the face of the earth.

No Longer Mere Theory.

Amazing prospects are thus opened to us but we hesitate for a moment and inquire, Is not this all perhaps theory?

Replying to this question, I would say that it has been possible for some time past to purchase from various laboratories in this country pure cultures of certain bacteria with which to inoculate the roots and soil for the growth of certain specific crops and remarkable results in the increase of the same have forever placed this matter beyond the theoretical stage.

The first notice of this discovery dates back nearly 30 years and was brought forward by two German agricultural chemists, Hellriegel and Wilfarth, and the bacteria infesting the roots of leguminous plants were by them named bacillus radicola. Their experiments were later followed and improved by many earnest students endeavoring to make their discoveries a marketable commodity. Professor Nobbe sold the bacteria in gelatin, but after a time they became over-fed and lazy and refused to perform their required function of fixing nitrogen from the air.

The United States Department of Agriculture went a step farther in 1901 and distributed the bacteria on cotton wool. The results of introducing these into soils were attended in many cases with excellent results but their ultimate failure we now know was due to the fact that they retained their vitality in cotton for only about six weeks.

Two great problems now remained to be solved to insure complete success in soil inoculation—first, to find a free growing azotobacter or nitrifying bacterium that was not dependent on the roots of anv particular plant for its support or existence, but that might equally feed nitrogen to any plant needing it, and growing freely in the soil, and, secondly, to find some soil or medium suitable to the propagation or support of the animalcule in question.

It seems to have remained for Prof. W. B. Bottomly, of Kew Gardens, near London, England, to make this enormously important constructive discovery.

Selected Humus from Peat.

It was first necessary to discover and confirm the cause of the many failures in the propagation and preservation of the useful bacteria, owing to lack of moisture, acidity of soil, excess of nitrates, and so on, and as a result he selected humus from peat as food for the plant-feeding bacteria. This, after treatment with a mixed culture of bacteria which he discovered in decayed animal matter, was named by him "Humogen."

Under proper conditions of moisture and temperature these cultures will spread rapidly through the soil, far and wide beyond the spots where they were first introduced, and one thinks of any acre being fertilized from one inch of bacterised peat.

The practical results from the use of "humogen" or treated peat have been little short of marvellous and the commercial value of this substance is moderately fixed as $50 a ton, based on results of other fertilizers of the same value. In 1913, in one experiment with potatoes, the use of "humogen" gave 123 per cent. better results than were obtained on unfertilized soils, 75 per cent. better than with the best known fertilizers, and 41 per cent. better than with barnyard manure.

To encourage those who might be inclined to say that nothing could result to the average farmer from all this information, as he does not have the services of the trained bacteriologist or microscopist, I may give some results of my own experiments along these lines for the past two years.

Without knowing anything for a time of the efforts of Professor Bottomley, I was constantly at work to improve my muck and peat products and to convert them into humus, by first excavating and seasoning as long as possible in the sun, grinding as fine as possible, and introducing various forms of decayed animal matter to enrich it and to start the growth of suitable bacteria.

Unwittingly I started in where Professor Bottomley left off, with peaty muck, and results were quickly apparent in the rising temperature of the ground and seasoned muck piles kept in dark storage, the growth of fungi in the material and the rich leaf mould smell, and the appearance of the finished product.

Under the microscope I found countless colonies of bacteria, and all to whom I sent this prepared humus for experiments on their gardens and lawns had the most gratifying results.

In citrus groves where the trees were so famished for humus that the owners had about concluded to dig up and remove the trees, and where fertilizers of all kinds had been tried without results, a new lease of life seemed to be given, and fine growth and large fruiting resulted.

Last week I received, from a citrus grower of 35 years' experience on Indian River, who has given close attention to the matter, a letter in which he says:

"I think you will have ample opportunity to prove your contention that the peat and muck beds of Florida are among her most valuable assets."

Far from wishing to be understood as asserting that soil inoculation will do away with the use of chemical commercial fertilizers, my belief is that properly selected chemicals will vastly enhance and encourage the growth of bacteria, while others now used may be ruled out as detrimental to the same.

Quoting Newton, the great philosopher, we realize that with all our study we are only picking up shells on the shore of the vast ocean of science, and we must be careful, while studying the new methods, not to forget the old, but when introduced to new lines of thought by such students as Professor Bottomley, it will tend vastly to our benefit if we follow along the lines thus indicated and by putting a little more labor on our brains we may save a good deal of labor with our hands and largely benefit ourselves and our fellow men.

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EDITORIAL NOTES

Peat and the European Crisis. The present European crisis has created a world-wide interest in the economic uses of peat in agriculture as well as in the industries, not only in the belligerent countries themselves but also in some of the neutral countries, especially Scandinavia and Holland. Several references to the present activities will be found in this issue. We even hear echoes again of projects from Ireland, where lately there has been a revival of effort in this direction. Among those who have interested themselves in the Irish peat industry is L. Ginnell, M. P., about whose work we report elsewhere in this issue. The Midland Peat Industries Committee, which resulted from the recent meeting at Mullingar, Ireland, has for its object the institution of further investigations with a view to issuing a prospectus and forming a company for the manufacture of condensed peat, charcoal, and other commodities. Because of the extent or area of bogland in the midland counties of Ireland, the project is one of interest and importance to the people resident in its vicinity and if successful it should create a new and prosperous industry. At present the committee is devoting itself to ascertaining the areas and depths of bogs that are available for their purpose.

The agricultural uses of peat in Ireland have not been lost sight of, as Professor Bottomley's experiments have created enough interest to raise Ireland's hopes for an increased home-grown food supply.

In Denmark, as well as the other Scandinavian countries, the tendency appears to be chiefly the greater technical use of peat, especially to improve its quality as fuel and to recover its by-products and ammonia. In Sweden, however, the metallurgical use of peat, as well as its direct use for fuel, can be easily comprehended. These countries are almost entirely dependent on outside sources for their fuel supply, which has been embarrassingly curtailed owing to the shipping conditions during the war. It is on this account that Holland once again is largely using peat as fuel, and also for making illuminating gas, as is explained elsewhere.

Germany is realizing today more than ever the economic value of her peat deposits as an agricultural asset. Not only is the sphagnum moss declared to be of equal value in the medical science to sterilized absorbent cotton, but the peat layers below the moss are being used as packing material for fruit and other materials, while the denser peat is dried and rubbed to coarse grains to take the place of cork as an insulating material. This economic utilization of Nature's resources should not be overlooked by our American people.

Even Great Britain is tardily waking up to the latent virtues of her peat soils; we hear also, from England, that sphagnum moss has been extensively used in surgery as a dressing for wounds. Under our abstracts will be found a description of a peat-distillation process. Moreover, profound interest has been created by Professor Bottomley's work, and even our daily newspapers contain columns on the subject.

Coming to America, we have not yet properly realized the resources in our peat deposits, neither have the European conditions helped us any. The primary use of peat here is in agriculture, and we were as early as the Europeans in recognizing its value for this purpose, yet today some of the State agricultural stations are still living in the past and consider peat fertilizer and peat soil as worthless, despite the fact that some of our best farms are either on peat soil or on soils containing large admixtures of peat and mixed with humus. In Canada, on the other hand, peat is being more readily accepted as a fuel and as an agricultural asset.

In the present circumstances, considering the high prices of distillation products, the utilization of peat as a fuel, and also converting it into coke in retorts, thus obtaining its chemical by-products, would appear very tempting to capital.

Because of the nature and properties of peat, in order to prepare it for use as fuel, the obvious matter of chief importance is to free it as far as possible from the excessive amount of water it contains. From the earliest times this result has usually been effected by draining the peat bog, the superficial layers, when the water has run off, being cut into thin slices and exposed on the top of the bog to the drying action of the sun and air. It has been observed, moreover, that any mechanical process by which the fibers of the peat are crushed and torn asunder tends to increase the density and compactness of the resultant fuel, and therefore some of the principal systems adopted for what may be termed the artificial preparation of peat, as opposed to the simple drainage and hand cutting and drying, aim at the destruction of the fibrous constituents by various means.

Hand-cut peat is such a bulky fuel that it has never been found possible to transport it to great distances from the bog on terms permitting it to compete with coal, and therefore many inventors have attempted to consolidate the raw peat and at the same time to extract the superabundant moisture, the agencies employed being heat, pressure, pugging processes, and centrifugal force in machines of the "wringer" type. The number of mechanical systems of treating peat introduced from time to time has been legion, but in the long run it cannot be said that any system of consolidation has been found to be really effectual. The peat thus treated will not, in fact, stand the additional costs of the manufacture.

Another obvious method for obtaining a more valuable fuel from peat, based upon the treatment adopted for wood, is to convert it into charcoal. The preparation of charcoal or coke from peat has received a surprising amount of attention and in recent years the charring of peat, taken in connection with the conservation of the volatile distillates, has been extensively practised, with results of a very encouraging character, especially in countries where coal is scarce. The chemical processes involved in the successful utilization of the gaseous elements contained in the peat require a high degree of technical skill, as will be evident from accounts of the Ziegler, Woltereck, and other systems, but there would seem to be no large margin of profit possible when the costly nature of the plant is considered.

Among the most recent improvements in the use of peat for power production, its employment in a semi-dry state in the gas-producer must undoubtedly take a high rank. Indeed, where the peat can be consumed on the bog itself for the generation of gas, from which the more valuable portions, as ammonia, wood alcohol, etc., are extracted for separate manufacture, while the residue can be converted into electric power by means of the gas engine and dynamo and readily transmitted for use at a distance,

the problem of the economical employment of peat would seem to be solved. In this way the obstacles opposed by the bulky nature of this fuel can to some extent be overcome, and its valuable constituents are conserved. The employment of peat in this manner has been rendered possible by the researches of the late Dr. Ludwig Mond, who was the first to show that moist peat with as much as 50 per cent. of water can be used in the gas producer; this process is now in operation on the continent of Europe, in Italy and also in Germany.

Distribution of Peat. With the sole exception of wood, there is probably no material used for fuel purposes that has so wide a distribution through the world as peat, and but for the fact that it invariably occurs in nature mixed with a high percentage of water, it would probably constitute an exceedingly valuable source of combustible matter. It may not be so long before peat bogs will constitute an important fuel supply.

The following figures will give some approximate idea of the extent of peat bogs in Europe and America:

	Acres
Russia (in Europe)	93,900,000
Canada	25,600,000
Finland	18,280,000
Sweden	12,857,000
United States	7,161,000
Germany	7,010,000
Norway	3,950,000
Great Britain	3,500,000
Ireland	2,858,000
Holland	246,000
Denmark	200,000
Austria	65,000
Italy (Lombardy alone)	3,000
	175,630,000

One of the largest accumulations of peat in England is the famous Chat Moss Bog in Lancashire, with an area of over 6,000 acres. This bog, which is only slightly elevated above the sea, is in places 20 to 30 feet deep. Moss Flanders, in Perthshire, Scotland, extends to about 10,000 acres, but these figures sink in insignificance when compared with the immense Bog of Allen, in Ireland, which at one time covered not less than 1,000,000 acres, but is now reduced by drainage and cultivation to an area of about 300,000 acres. Perhaps the most extensive surface of peat in the world is found in the Everglades of Florida, which are said to spread over more than 4,000 square miles (2,500,000 acres). For the larger part of this area there is a depth of several feet of vegetable matter.

Next Anuual Meeting. At our last annual meeting it was voted that the next annual meeting of our Society should be held in St. Augustine, Fla., in either November or December of this year. Since the publication of the proceedings of the Detroit Meeting, our Secretary reports that he has received several communications which in general signify that it is a long and expensive trip to St. Augustine and if we try to meet there we would have only a handful of members present. Mr. Ransom, of St. Augustine, was present at our Detroit Meeting and urged the holding of the next meeting there as due his State, which contains the largest peat deposits in the country. He thought we ought to help the people out who have the Everglades on their hands, and it was finally voted at the meeting to go there. It should be borne in mind that one of the weak features of our Detroit meeting was the lack of attendance of members. and, therefore, the passing of the resolution to meet in Florida was not, perhaps, the choice of our total membership.

Ithaca, N. Y., as well as Rochester, has been intimated as a desirable place for our next meeting and it has also been indicated that either place is more centrally located to attract our members from the Middle West and the northern part of the States, as well as in convenient reach of our Canadian members.

It is undoubtedly true that the American Peat Society would do much good to the Florida holders of peat land, by holding a meeting in that State, yet, on the other hand, our membership in Florida is composed of only one member, while the States of the northeastern quarter of the country contain the bulk of our membership. It would be highly desirable to have as many of our members as possible communicate with our Secretary, Mr. Julius Bordollo, Kingsbridge, New York City, their opinion as to where they would desire the next meeting to be held. Our members are requested to act promptly on this matter, as it will be necessary for our Executive Committee to make arrangements very shortly for the next annual meeting, and the Society should certainly benefit by meeting at a place that represents the choice of a majority of our members. so that a large attendance can be expected.

Professor Davis Seriously Ill. The Editorial Committee is sorry to announce that as copy for the April issue of the Journal is being prepared for press, Prof. C. A. Davis, the long-time and highly esteemed editor of the Journal, is suffering from a serious illness, brought on by overwork. The many warm friends of Professor Davis in the Americana Peat Society will wish for him an early return of permanent good health.

ERRATA.

In the Journal's report of the Proceedings of the Ninth Annual Convention of the Society (Vol. 8, p. 120), the statement "by a well arranged display of samples of grains and grasses grown in the course of the experimental work described," credited to Prof. F. J. Alway, should have been attached to the paragraph reporting Mr. Otto I. Berg's demonstration on page 121.

The author of "The Use of Peat in Commercial Fertilizer," in our last issue, page 28, should read H. E. Wiedemann and not H. E. Wildeman.

WHITE MOSS.

A very bulky type of wet fuel is furnished by the so-called "white moss" in Scandinavia. This is really a growth of sphagnum in damp places, or on the surface of the bogs, and such moss covers large tracts in the midlands of Sweden. By passing the wet material between rollers, the amount of water present may be reduced to 50 per cent. It appears that the calorific value of this material is 4,300 to 4,700 B. t. u. per pound, so that with 50 per cent of moisture it would have the heating effect of about one-third of its weight of good coal. In the case of a plant with two pairs of rollers in train, employing about 15 horsepower, it was found possible to produce about 1 ton per hour of the pressed moss, and even when the material was passed several times thru the rolls the percentage of water was not further reduced. In using the coarse pressed moss, somewhat resembling damp sawdust, it was ascertained that a mixture of 70 per cent of this substance with 30 per cent of air-dried peat furnished good results in the gas producer. In an official trial of this fuel conducted at a tube-welding furnace at Storfors, in Sweden, 616 kg. of air-dried white moss, containing a little over 38 per cent. of water, cut up into pieces, gave out as much heat as 356 kg. of steam coal. This estimate, however, leaves out of consideration the large volume of combustible gas evolved by the dried moss.

Abstracts, Patents, Etc.

Dr. Herbert Philip, Perth Amboy, N. J.

Development of Canadian Peat Bogs. Attention is being drawn to the possibility of expansion of Canadian commerce and industry as a result of the war. This may take the form of domestic production of articles for a supply of which we have been dependent upon foreign sources, or of increased exports to other countries of products hitherto supplied by Germany and Austria.

Among other things this emphasizes the importance which development of the latent resources of Canadian peat bogs might readily assume if full advantage of the new conditions arising from the war were taken.

Sulphate of ammonia, the chief by-product of European peat plants, is a valuable fertilizer worth about $60 per ton. The world's production last year is estimated at 1,365,000 tons, worth about $80,000,000. The chief importing countries are as follows, the figures representing excess of consumption over production.

	Tons	Value
United States and Canada	58,000	$ 3,500,000
Japan	115,000	7,000,000
Java	57,000	3,500,000
France	15,000	900,000
Spain and Portugal	42,000	2,500,000
Italy	15,000	900,000
	302,000	$18,300,000

Of these amounts the portion supplies by Germany and Austria was:

	Tons	Value
Germany	90,000	$ 5,400,000
Austria	30,000	1,800,000
	120,000	$ 7,200,000

These figures show the existence of extensive markets which might be supplied, in part at least, by Canada, and of an opportunity to capture some share of the trade of Germany and Austria in this product.

The extent and rapid growth of the domestic market for artificial fertilizers is shown by the following statement of Canadian imports for 1902 and 1903 and the past six years:

Year	Value	Year	Value
1902	$ 84,990	1903	$112,256
1908	403,171	1911	586,453
1909	529,660	1912	620,147
1910	548,493	1913	737,656

Many Canadian peat bogs are rich in nitrogen, and therefore suitable for this industry, and inquiries have already been made by British capitalists with a view to establishing chemical works in Canada, provided a sufficient supply of peat can be guaranteed.

Apart from the potential value of our peat bogs as a subsidiary source of fuel supply and for production of sulphate of ammonia, there are numerous other products, such as moss litter, peat dust, alcohol, acetic acid, acetone, tar, tar oils, creosote, etc., which might form the basis of paying industries giving employment to many people, where now we have only waste lands.

In the peat bogs of Northern Holland alone it is stated that about $3,000,000 worth of peat fuel is made yearly, and over 200,000 tons of peat moss litter. About 10,000 families are employed in the peat fields, and many prosperous towns owe their existence and prosperity to the industry. In addition to shipments made by rail, it is estimated that peat furnishes annually about 48,000 cargoes to the Dutch canal boats.—Journal of the Canadian Peat Society.

Peat Fuel in Russia. An abstract of a paper read before the Mechanical Engineers' Section of the Polytechnical Society in Moscow, Russia, by John H. Gibson, manager of peat and charcoal manufacturing plants of P. P. Demidoff's successors, Nijni-Taguil District, Government of Perm, Russia.

The deposits of peat in Russia are rather difficult to calculate. Count Vasiltchikoff, in one of the official organs of the Ministry of Agriculture, estimates the area of bogs in Russia at approximately 770,000 square kilometers. German statistical reports estimate the area at 350,000 square kilometers and, for Finland, 73,700 square kilometers.

The records of the expedition of General Jilinsky mention 1,355 square kilometers in only one government of Minsk. In central Russia the area covered by the estuaries of the River Oka (Schva, Colodcha, Pra, Wokscha, etc.), includes 1,760 square kilometers, and the basin of the estuaries of the River Kliazma includes about 1,100 square kilometers of peat bogs. The northeast side of the government of Moscow and Tver has about 550 square kilometers. There is one particular peat bog, "Orschinsky Moh," which alone covers 1,100 square kilometers.

The peat-investigation branch of the Ministry of Agriculture has investigated about 1,760 square kilometers of the Government peat bogs as per Table 2. The peat deposits of the bogs investigated from 1882 up to 1911 contain 3,868,000,000 cubic meters of peat, or 1,289,000 cubic meters of air-dried peat fuel. About 50 per cent. of the investigated areas belong to the Governments of Moscow, Vladimir, Tver, Riazan, and Nijni-Novgorod, and are distributed as per Table 2. Compared with the present output of 3,000,000 tons of air-dried peat fuel per annum, the above quantity would last at least 20 years.

The peat industry of Russia, as a commercial enterprise, had its beginning in the last quarter of the Nineteenth century. However, some pioneer work in developing the bogs was undertaken as early as the time of Peter the Great, who found the practical men for the industry in the classical peat country of Holland, and brought them over to Russia. In 1765 the Imperial Free Economical Society inserted in its journal an article on "Peat and Its Charring Into Coal," written by a Mr. Leman. Later the society inaugurated a system of premiums to encourage the use of peat. As a result of the efforts of the society, many private people started their own peat lands; for instance, Count Kourakin in the Government of Orel, and Mr. Madox, an Englishman, in the Government of Smolensk, whose plant, situated in the Gjatsky District, had an output of 50,000 bricks of hand-cut peat per annum in 1793. One of the first peat plants in the central region of Russia was installed by the government for the Ismaylowski brick works near Moscow. In 1837 Count Kiseleff, minister for the state estates, issued a circular instructing the provincial offices of his department to collect information with regard to the peat industry, and two torfmeisters were brought from the Baltic provinces to investigate the peat bogs and superintend their working. In 1840 a decree was issued by the Emperor for the heating of the Government buildings at Moscow by peat instead of wood, and in 1851 a special committee was formed under the presidency of Count Zakrevsky, governor general of Moscow, to work for the development of the peat industry.

Table 1—Area of Peat Bogs Investigated in Central Russia. 1900-1911.

	Square Kilometers		Square Kilometers
1900	72	1906	127
1901	95	1907	126
1902	49	1908	110
1903	25	1909	160
1904	128	1910	211
1905	53	1911	405

For the successful achievement of this object the committee were empowered to support private enterprise by granting long-time loans on easy terms. Shortly after the committee began its operations, 160,000 cubic meters of hand-cut peat fuel was made at one of the peat bogs situated near Moscow, which was forwarded by order of the governor general to the nearest manufactories. Large quantities of this peat were thrown aside, and manufactories continued to use wood as before.

Up to 1870 only hand-cut peat was made. In 1875 a Government peat plant was erected in the Karatchewsky District of the Government of Orel, where machines were used of the Gratzian-Pio and Dolberg types. With the extension of manufacturing industries and the consequently increased prices of wood, the use of peat fuel gradually became more and more extensive. Comparing the direction in which peat-machine manufacturers in Russia and other parts of Europe developed their machines, it may be observed that in Russia efforts were principally devoted to the introduction of better methods of cutting, mixing, and pulping peat, instead of increasing output and lessening the number of workmen employed. But the steady increase in wages and the great demand for skilled peat men have had the effect that endeavors are now being made to introduce into the peat industry "American methods," as they are called in Russia; that is, to introduce more machinery and to lessen the labor. The machines most used in Russia are those of Anrep design and similar types, but it may be said generally that there are as many types as installations. A new type that is spreading very rapidly now is the Hendune machine.

Table 2—Area of Peat Bogs in Central Russia Investigated by Government, 1882-1911.

Square Kilometers	Government	Square Kilometers	Government
1,118	Tver	136	Riazan
315	Vladimir	80	Nishni Novgorod
160	Moscow		

The output of machine peat is increasing year by year. In 1893 the output of eleven Governments (Vladimir, Moscow, Nijni-Novgorod, Riazan, Kursk, Tamboff, Perm, Warsaw, Kalish, Loublin, and Petrokoff), was 1,100,000 tons. In three years th output of the Governments, produced by 73 peat plants, was as follows:

Year	Tons	Year	Tons
1908	1,000,000	1910	1,230,000
1909	1,075,000		

This peat is used exclusively by manufacturing industries—cotton and weaving mills, brick works, glass works, iron and steel works, etc. The late Aleph Anrep estimated that at the beginning of the present century 1,300 peat machines were in use in Russia. If the average yearly production of a machine is assumed as being 5,000 cubic meters, which is rather a low figure, the production at that time must have been about 2,700,000 tons of air-dried peat fuel per annum.

To give some idea of the size of some of the peat plants now operating in Russia, I may mention that Morosoff, Son & Co., at Orehowo, near Moscow, where more than 50 machines are working every season, and a similar sized plant of the Electric Lighting Co., recently started, and so on.

The scarcity and high prices of naphtha and coal, the two chief classes of fuel in Russia, have had the effect that peat fuel plants are now spreading all over the country by leaps and bounds. During the season of 1914, one peat-machine manufacturer received orders for more than 100 machines with equipment; another for 50, and so on. Prospectors are traveling the country over in search of suitable peat bogs, and are selling at high prices the information obtained. There is in fact a real boom in the peat industry. The retail price of machine peat in Moscow is now $4.80 per ton, instead of $3 per ton, the price three years ago.—Journal of the Canadian Peat Society, 1915.

Uses of Sphagnum Moss in England. Owing to the great European war and paralleling the development of synthetic substitutes to meet the lack of articles previously obtainable, the shortage of prepared cotton wool for surgical uses has been overcome by the utilization of certain forms of sphagnaceæ, the peat moss so common to the bogs of England and Scotland. Its recent use strengthens the claim advanced by many scientists that somewhere Dame Nature has provided for every want of mankind.

From a surgical standpoint, it is said that in many ways the sphagnum moss is superior to other dressings. Its structure is such that it has an enormous capacity for the absorption of moisture, such as wound seepage, for the cellular processes quickly lead such extraneous acquisitions from the direct point of absorption and distribute them throughout the extent of the pad or compress made of the moss. This is highly desirable, for with the cotton wool, liquids quickly work through to bandages, clothing or bedding, to their detriment.

Sphagnum is much more springy than cotton wool, and its touch upon the bare skin is grateful to patients unfortunate enough to require a surgical dressing of any description.

These springy qualities are particularly beneficial beneath bandages, for the material does not mat under the necessary compression applied and the interstices permit a wholesome circulation of air, owing to its structure, a condition considered as highly favoring antisepsis.

The absorbing power of the moss is remarkable, being without undue preparation approximately seven times its own weight in water.

With the economic problems existing under the necessity for enormous expenditures to meet the demands of the military service, the general use of sphagnum commends itself to those in disbursing authority as well as to the medical corps. It has been estimated that, were cotton wool used exclusively in the hospital service, the cost would be not less than $200,000 per anuum throughout the war to Great Britain alone, while the cost of the moss is practically negligible.

As sphagnum is generally plentiful and accessible, comparatively few people are required for its collection and preparation. Committees of volunteer workers have been accorded authority by the deputy surveyor in the New Forest section of Great Britain to collect the moss for hospital use. While the dressing has not yet come into exclusive use it is expected that enormously greater quantities will be sent to the various lines of hospital service within a short time, than have been used hitherto.

The moss grows in tufts and large masses in and about bogs, whence it is pulled by hand. It is then dried upon netting in the open air so as to get as free a circulation as possible around it. After the first drying, it is carefully picked over so that all bits of foreign matter, such as grass, heather, leaves and twigs, may be removed.

Following its cleaning, the moss is sterilized. After a final drying it is then packed in muslin bags of convenient size for shipment in case lots.

According to the report of the American consul at Bradford, England, many cases of these dressings have so far been used in hospitals at Boulogne and elsewhere in France, and by French and Belgian hospitals in addition to its use in British service. In other theatres of war, sphagnum has been used at Malta, Alexandria, Gallipoli, and in Serbia.

In the United States, sphagnum has for some time been in common use by florists and horticulturalists as a resilient medium for the packing of plants and trees. In addition, it has been used instead of earth for growing certain plants. A number of varieties of orchids, according to the observation of an eminent botanist, flourish as well in sphagnum as in their normal, cool haunts in native forest depths.

Its use by florists, however, now seems to be decreasing. Formerly the moisture-retaining property of sphagnum was valuable in the making of floral baskets. The custom of lining flower baskets with zinc water containers is now so general that the utilization of the moss is practically restricted to forming the bases of floral emblems.—Scientific American.

Peat in Denmark. The Torvekvalstorf Kompagniet has been formed in Denmark for the purpose of gaining nitrogen products from peat by the C. F. Maule process. Gas is also produced as a by-product.

It is hoped that this process will prove profitable for Denmark with its large peat deposits. Experimental plants are being erected at Nyborg in Fuenen and at the Holingaard glass factory in Sjalland.

(I presume that the C. F. Maule process referred to is the one described in British Patent 722, of January 9, 1913—process for the simultaneous production of nitrogenous compounds and combustible gas from nitrogenous fuel. In this process the temperature of the producer is lowered to about 600° to 650° C.; that is, considerably below the ignition temperature, to avoid risk of explosions, by introducing below the grate, together with the air, a part of the cooled combustible gaseous mixture produced. The gas so reintroduced into the producer is saturated with moisture and has its temperature reduced to about 150° C. This is attained by using peat containing up to 60 per cent, of moisture.—H. P.)

Peat Moss from Germany. The consulate at Hanover for the United States reports that among the commodities invoiced at his office during 1914 for export to the United States was peat moss valued at $7,744.

Swedish Peat Developments. Efforts are being made in Sweden to develop the numerous peat bogs in that country, and two factories at Fristad and Stafsjö are being established. A syndicate of influential persons has also purchased the Vakö bog, near the Sölvesborg-Elmhults Railway, Scania, with a view to erecting a factory for making peat powder, and eventually peat bricks, by the Porat and Odelstierna process. The annual production of peat powder at this factory is estimated at 25,000 tons.

Peat Litter in Ireland. During the fiscal year of 1913, Ireland imported 2,562 tons of peat litter, valued at $16,001. The export-trade returns for 1913 show that 2,117 tons of peat litter was exported, at a value of $13,222. A consular report states that peat is not used in Ireland except under necessity, although in the western sections active turbaries (peat-grinding plants), are frequently to be seen. There is 1,576 acres of flat bogs in Ireland, and at the present rate of consumption the supply is inexhaustible. Governmental experiments, however, appear to show that peat is hardly worth developing.

Gas from Peat. According to a Friesland newspaper, the municipal gas works at Akkrum, in that province, is extracting gas from peat mixed with coal. It is stated that if peat alone were used, the retorts would become too hot, because of the steam created by the moisture always found in peat. Accordingly the retorts are filled with two parts in weight of coal to one part of peat.

The peat—as well as the coal—produces about 30 cubic meters of gas per 100 kilos (220.46 pounds). The gas produced from this mixture is declared to be of excellent quality.

The peat is entirely consumed in the process, and therefore yields no by-products, as coal does in tar and coke. But the use of peat is a great saving of coal, which is important in Holland now, with all coal, and particularly gas coal, scarce unless imported from a great distance at heavy cost. Peat, particularly in Friesland, is plentiful. and is dug in the vicinity of the gas works. —Consular Report, September 3, 1915.

Ground Peat Wanted in Canary Islands. An exceptional opportunity to supply the Canary Islands with ground peat, commercially known as "turba," is open to owners of peat properties in the United States. There is an almost absolute lack of this material, which is there considered indispensable for the dry packing of tomatoes and the damp packing of new potatoes, two vegetables that are exported in very large quantities to England.

Close calculations, made especially for the Teneriffe consulate by firms representing at least 90 per cent. of the total consumption of ground peat in the district mentioned, show that approximately 3,000 tons is urgently needed to handle the coming crops of potatoes and tomatoes. These two crops will be in full course of exportation by December, 1915, and will continue until May, 1916; and packers will practically be compelled to pay almost any price to European producers of ground peat unless a supply can be obtained from other sources.

Just at this time fruit shippers are paying extraordinary prices for the small quantities being used in this by-season. In order to fill a contract two weeks ago a local commission house was forced to pay $26.40 per ton for ground peat, of which the price in July, 1914, was $9.60. This was certainly an exceptional case and one in which the price paid was a forced figure, owing to the contract necessities of the firm.

On the other hand, the regular guaranteed delivery price for "turba" at this date is $24 per ton c. i. f. Canary ports in lots of 100 tons or more. At a recent consultation of the principal buyers of ground peat in Teneriffe, brought together by me to consider the chances of American-ground peat for use between October, 1915, and May, 1916, it was agreed that if it could be landed here at a price between $19.20 and $21.60 it could undersell the supply from any other market. This is emphasized by the fact that 100 tons of ground peat was bought in England yesterday at $22.80 per ton. This offer was snapped up as a bargain by cable.

The proposition, however, from the American viewpoint, cannot well be solved by small lot orders. It is generally agreed here among the important buyers that the best way for American producers to handle the ground-peat problem would be to load a sailing vessel with practically an entire cargo of ground peat. This cargo could safely approximate 3,000 tons. In this way the freight charges could be reduced to a point where they could compete with those for the shorter haul from Liverpool.

Moreover, there are four buyers of ground peat who claim at this time to be willing to place orders totaling 2,000 tons at a minimum price of $19.20 per ton. Of course this standard of price is entirely contingent upon the continuation of war conditions, and for this reason buyers here are unwilling to take on a larger stock at this time than indicated above. As promptness is essential, it is of the utmost importance that samples be sent with offers and that prices f. o. b. American port, or, if possible, c. i. f. a Canary port, be quoted, as well as time of deliveries.

To meet a quick sale here the peat must first be thoroughly dried, the maximum percentage of moisture not exceeding 10 per cent, at time of packing, as the sea voyage can be counted on usually to add an extra 3 per cent. of humidity before actual delivery in Canary ports. After drying, the peat should be ground extremely fine and soft. It should be odorless, as otherwise it seriously affects the flavor of the tomatoes packed in it. Another important point is the absence of sticks or lumps.

"Turba" should be packed in hessian-covered bales of 100 kilos (220.46 pounds avoirdupois), which gives 10 bales to the tonelada or metric ton. However, bales approximating 200 pounds and counting 10 to the ton would be acceptable commer-

cially here. The ground-peat bales should be strongly compressed by machinery and thoroughly bound with wire over wooden staves.—Consular Report, October 20, 1915.

Peat as a Fuel for Boilers. The scarcity of coal in the Netherlands since the war began has led to search and inquiry in all directions for relief by the use of substitutes or otherwise. Netherlands uses vast quantities of foreign coal yearly. In 1913 the imports totaled 22,429,730 tons; in 1914, 17,946,325 tons. Along this line, an Amsterdam newspaper prints an extract from a scientific journal stating that "turfpoeder" (peat in a powdery form), has long been used in Sweden as a fuel for stationary boilers, and that recent experiments in that country with railroad locomotive boilers show that 1⅓ tons of peat powder equal 1 ton of the best English coal for steaming purposes.

This leads the Amsterdam newspaper to remark that according to estimates the peat moors of the Netherlands contain at the present time fully 100,000 million kilos (about 100,000,000 long tons), of ready-to-burn peat, which is equivalent to about 75,000,000 tons of best English coal, according to the Swedish experiment, and that this fuel is immediately available. The newspaper adds that the price of "burgerturf" (a short, hard peat, burning a long time), is 11 to 13 florins ($4.42 to $5.23) per ton, while the best English coal costs 16 florins ($6.43).—Consular Report, November 19, 1915.

A New Peat-Distillation Process: A new process for the distillation of peat has recently been patented in Great Britain and other countries by which coke, fuel oil, toluol, ammonia, paraffin wax, and acetone are obtained in sufficient quantities and of such high grade as to prove of great value. The process has been in practical operation now some six months and seems to promise to revolutionize the peat industry and to furnish sources of fuel oil to the British Navy which may possibly make it independent of foreign oils.

Peat, as taken from the peat beds, contains from 80 to 90 per cent. of water and is of a fibrous cellular structure so that by hydraulic pressure it is possible to lower the water content only slightly. An important part of the new process is a macerator that breaks up the fibrous cellular tissue and thus allows a more complete separation of the water. After passing through the macerator the broken peat is compressed into briquets, which are dried until they contain not more than 25 per cent. of moisture, and then fed into a hopper from which they pass into the retort.

This retort, though very simple, is the basis of the patent. It contains several chambers where different degrees of heat are

applied. In the first a temperature of 300° C. (572° F.) is used for driving out the moisture remaining in the peat. In the next chamber the temperature is about 450° C. (842° F.), and here decomposition of the peat takes place. In the last chambers the temperature runs up to 600° or 800° C. (1,112° to 1,472° F.), and the oil and water are volatilized. By means of a worm screw, briquetted peat is passed in at one end of the retort and peat charcoal is discharged continuously at the other end, while from the various chambers the oil, water, ammonia, etc., are drawn off in the form of vapor and removed from longer contact with the heat.

After leaving the chambers the vapors pass through a condensing system which is so arranged that the heavy oil collects at one place and the water and light oil in the form of vapor, together with some combustible gases, collect in another place. The combustible gases are separated from the water and oil and are utilized in keeping up the temperature of the retort, after it has obtained its initial heat from coal, and they are ordinarily sufficient to carry on the subsequent processes without the addition of any further coal.

The coke obtained by this process contains 92 per cent. carbon, 1 per cent. moisture, 1.3 per cent. volatile matter, and 5.7 per cent. ash, and is very hard. It can be left with a larger percentage of moisture, and in this way, as it is softer, it can be used for fuel for domestic purposes. Its chief value, however, is in the manufacture of steel, owing to its wonderful hardness and the high percentage of carbon contained. Various steel makers have certified to its great value for this purpose. From a ton of peat nearly one-third of a ton of coke, valued at 25 to 30 shillings ($6.08 to $7.30) is obtained.

The oil promises to be particularly useful as a fuel because of its low sulphur content. An examination of the oil showed it to be a most satisfactory substitute for petroleum. The amount of ammonia obtained per ton of peat is estimated at 20 pounds, with a value of 1 penny (2 cents) or more per pound. Both the oil and the ammonia contain water, but this is readily removed by the application of heat. In addition to these products about 20 pounds of paraffin wax, valued at 3 or 4 pence (6 or 8 cents) per pound, is obtained, and toluol and acetone; the quantity and value of the latter have not yet been ascertained. The paraffin wax is of good quality and can be employed for candle making and other purposes.

With peat costing about 8 shillings ($1.95) per ton delivered in the hopper, dry, it is believed that by this process a profit of not less than 15 or 20 shillings ($3.65 or $4.87) per ton will be obtained: and this does not include any allowance for the toluol and acetone, which may prove to be more valuable than all the other products together.

Peat from different localities gives different results, some peat containing larger amounts of volatile matter than others, and some peat having a low nitrogen content, while in others it is high. The yield of oil from English peat (Yorkshire) was 26.5 gallons per ton. By varying the conditions of distillation, light or heavy oils may be produced as desired. The yield of oil, gas, and ammonium sulphate can be controlled by regulating the length of time or the degree of heat to which the peat is subjected in the retort.

Of the many attempts that have been made to utilize peat this method is said by many experts to promise most.—Consular Report, Nov. 19, 1915.

Iron Ore in Holland Under Peat Deposit: At one time iron ore was found in considerable quantities in the northeasterly Provinces of the Netherlands. In late years apparently less has been found. Recently, however, further deposits of iron ore have been found in the Province of Drenthe, where it was discovered previously. These deposits were revealed by the digging of peat in the bogs of that section. The ore is found in layers just under the peat, and also in collections or heaps 6 to 10 feet high and 30 to 50 feet in circumference.—Consular Report, Jan. 17, 1916.

Conversion of Irish Peat Into Manure: Irish agriculturalists are greatly interested in the alleged discovery of a method of converting ordinary peat into a highly concentrated fertilizer by a simple and inexpensive bacterial treatment. The discoverer is Prof. W. B. Bottomley, of the Royal Botanic Society, and his experiments have been indorsed by many British scientists and organizations of high reputation. Prof. Bottomley's principle is that bacteria facilitate the chemical processes connected with plant growth, and the peat bacterial culture immensely facilitates food absorption by vegetables and other farm crops. He has exhibited specimens of manure potatoes grown in seven weeks by the use of the peat fertilizer, and states that an acre of land treated with 1 ton of the peat manure has produced 41 per cent. more potatoes than an acre treated with 80 tons of ordinary farm manure. The manufacture of the peat fertilizer is so simple that it is being carried on by a man and a boy.

The British Board of Agriculture is not yet convinced that the value of the new manure has been demonstrated on a broad scale, and consequently has declined to take it over. A commercial company is partly organized, but Prof. Bottomley is anxious to have a national committee formed that will utilize his product at once. The council of the Royal Botanic Society is taking steps toward the formation of such a committee.

The peat supply of Ireland has been much reduced during the past half century, and if cut for manufacture into fertilizer on a large scale there is some question whether the raw material would hold out for more than a few years.—Consular Report, Nov. 27, 1915

Peat Briquets: Peat and chalk are being extensively used, it is reported, for briquetting in Canada. The peat is mixed with coal breeze, and then pressed into briquets. Such fuel has been found efficient and economical. Chalk also, of which there are large deposits in Canada, can be converted into a profitable fuel. If the chalk is pulverized, and then combined with a certain percentage of breeze and solidified tar, the mixture being compressed into small briquets or pebbles about the size of an egg, the briquets burn with perfect satisfaction. The fuel has the advantage of being smokeless, has a high calorific value, and burns freely.—Chemical Trade Journal.

Bacterized Peat. Further reference to Prof. W. B. Bottomley's discovery of bacterized peat was made at a meeting in London on Monday. Professor Bottomley said that the process consisted in the treatment of ordinary peat by means of bacteria, and within four or six days the peat had turned into a black substance, which, by analysis was revealed as containing fifty times as much valuable plant food material as ordinary manure. It looked as if old Dame Nature had been storing up for the time when we should want manure, because the decomposition of peat had gone on to just that stage when it could best be treated with bacteria. All he had done was to find the bacteria that enabled the peat to be turned into the richest manure. The manufacture of the product was extremely simple, and was at present being carried out by a man and a boy.

What would be done with the discovery, he asked. There were three courses open. The Board of Agriculture might take it up for the benefit of the nation; it might be exploited by a commercial concern; or it might be utilized for the benefit of the nation by a national committee. The Board of Agriculture has said they could not take it up, and Mr. Aoland, in reply to a question in the House of Commons, has said that no result had yet been obtained which demonstrated its utility for agricultural purposes on a field scale.

Prof. Bottomley said that, with regard to the second course, he had received an offer that a company should be formed with a capital of £100,000, that a purchase price of 33,000 fully-paid pound shares should be given to him, and that he should receive

£1,000 a year as a consulting chemist to the company. He objected to that course, however, because of the enhanced price at which the peat would be sold to the public. At present, although the raw peat cost £2 10s a ton, it could be sold at a profit at £6 a ton. The authorities at King's College were willing to allow the use of their laboratories free to produce the bacteria if they could formulate a public scheme, and an offer had been made to put up part or all of the money required without interest.

Another gentleman had offered a peat bog and a building free. With such advantages could it not be distributed at less than cost price? For the period of the war he was willing to give all his knowledge and his work, and he hoped some definite scheme would result by which the country might benefit.

Mr. Watson, the curator of Kew Gardens, testified to the value of the peat in the various experiments he had carried out, and said he saw no reason why equally satisfactory results should not be obtained in field cultivation.—Chemical Trade Journal.

Inoculation of Crops With Peat Preparation. J. H. Voelcker—(Jour. Bd. of Agr., 1915). The peat preparation tested was introduced by Prof. Bottomley; with it was compared heated ordinary fen soil, the latter having given good results at Woburn in the past, in order to discover whether any results obtainable from the peat preparation might not be due purely to the organic and nitrogeneous matter supplied.

The crops tested were barley, peas, and mustard, and the peat preparation (one part to eight of soil) and the heated fen soil were added to the top 6 inches of soil in the pots. Compared with untreated soil, the peat preparation produced crops of mustard and barley much darker in color (the barley having a broader flag) and with peas a stonger growth and better color. The results with peas were vitiated by blight; those from mustard and barley were as follows:

Comparative Results of Growing Crops on Peat-treated Soil.

	Weight of green mustard crops, grams.		Weight of barley, grams.	
	1st Crop	2nd Crop	Corn	Straw
Ordinary soil	59.6	12.3	18.1	25.5
Ordinary soil, peat preparation	163.3	20.6	19.6	33.5
Ordinary soil, heated fen soil	71.8	20.0	14.0	27.1

With tomatoes the use of the peat preparation was compared with the use of nitrate of ammonia, both being applied

(**a**) once, with and without phosphate of potash, (**b**) twice, with and without phosphate of potash. The nitrate of ammonia was used in such quantity as to supply the same amount of nitrogen as the soluble nitrogen in the peat preparation. During the period of growth the tomatoes treated with the peat preparation were invariably of darker green color than the rest. The following weights of fruit were obtained:

Comparative Results of Growing Tomatoes on Peat-treated Soil.

	Applied once alone Grams	Applied twice alone Grams	Applied once with phosphate of potash Grams	Applied twice with phosphate of potash Grams
Soil having no treatment	1,114	....	....	....
Soil with added peat preparation	1,206	965	1,127	893
Soil with added nitrate of ammonia	1,211	1,096	1,043	1,285

The Manuring of Grass Land (Jour. Bd. of Agri., 1915). The following is stated in reference to peaty and moor soils: Soils rich in organic matter respond well to dressings of finely-ground raw mineral phosphate, particularly where the rainfall is abundant. An adequate supply of water, in conjunction with the carbonic acid always occurring in such soils, helps to render the phosphate available for plant growth. Under such conditions ground mineral phosphate is well worth attention at the present time.

It appears that excessive acidity and excessive alkalinity are both destructive of moss. Lime is known to eradicate moss on some soils; superphosphate or basic slag and kainit, particularly the first-named, has also had good effects. "Fogging" is also recommended, that is, allowing foggage to stand through the autumn for winter grazing; a practice followed in districts with a mild winter, for example, Wales and Southwestern England.

Russian Peat Deposits. In view of the scarcity of coal in Russia, the Russian Ministry of Agriculture has decided to take energetic measures in order to commence the exploitation of peat deposits, and has entered into communication with about 260 municipalities in provinces where such deposits are situated.

The Adsorption of Peat. Paul Rohland (Kolloid Zeit., 1915, Vol. 16, p. 146).

The adsorption experiments with peat give results similar to those obtained with clay and clayey soils, although the energy

of adsorption is less with peat soils. The simply constituted dyes are not adsorbed; of the anilin dyes the best are the blue and violet (methylene blue, methyl violet), then the reds (anilin red); next the artificial green dyes (malachite green, brilliant green) and of the animal colors, carmine. Contrary to colloidal clay, peat soils adsorb well dyes containing several nitrogen groups (safranine, vesuvine, phenylenediazometaphenylenediamine, fluoresceine, and eosine), and absorb very well vegetable dyes (natural indigo, blue wood.) As the aqueous extraction of peat soil is of a yellowish color, it is difficult to determine the adsorption of yellow dyes (metanil yellow, safran); on the other hand the yellow color of the peat soil is well adsorbed by colloidal clay. The filtrate of nigrosine after the adsorption is still colored weakly blue. Colloidal solutions (starch, iron hydrate) are adsorbed by peat, however in a very much less degree than by colloidal clay. Ionic adsorption could not be detected with peat or with colloidal clay; only water was absorbed, which in turn absorbed the salts.

Firing With Peat and Peat Coke. H. Winkelmann, (Zeit. f. Dampfkraft Betr., 1915, vol. 37, p. 82).

Trials under the locomobile boiler of a peat digging machine were carried out. The results show that with pressed peat, containing 16 to 17.6 per cent. moisture, 60 to 62 per cent. efficiency was obtained, and peat coke showed an efficiency of 67 to 68 per cent. The flue gases with peat coke reached 11.2 to 11.4 per cent. carbon dioxide, while 7.4 to 7.6 per cent. was obtained with pressed peat. The draught was maintained by a steam injector.

Peat coke is prepared in special retorts, 30 tons of raw peat giving 8 to 9 tons coke. Gas and tar are obtained as by-products; the former is used for heating the coke retorts or for driving gas engines, while the latter can be worked into creosote oils, paraffin, methyl alcohol, pitch, ammonium sulphate, acetate of lime, etc. Peat coke is especially serviceable for welding and in metallurgy, taking the place of the more costly charcoal. Peat coke is hard and can be easily shoveled; it does not slag or clinker. Further, odorless and smokeless combustion takes place. Its heating value is higher than that of charcoal. Therefore a larger and more extensive use of peat coke should prove commercially desirable.

Peat Industry Projected in Westmeath, Ireland. The high price of fuel and the growing scarcity of coal draws attention to our bogs once more. The development of our peat resources is taking shape in the form of a preliminary meeting held in Mullingar, September 25 (Greville Arms Hotel), to consider the ques-

tion of forming a company to establish and work a general peat industry in the County Westmeath. The meeting was for informal consultation on the project, but an official report was subsequently supplied. A number of merchants and some country gentlemen attended to the number of twenty-two, and letters and telegrams were received from fourteen others.

Mr. Laurence Ginnell, M. P., presided.

Two experts from London, Sir Edward Zohrab, Bart., and Colonel Warburton submitted results of various processes whereby peat condensed to the hardness and efficiency of coal, peat charcoal for the purification of iron, steel, and many other valuable products, can be produced, with estimates of the cost of machinery. Mr. David Sherlock, owner of Rahan Peat Works, also gave the benefit of his experience to the meeting.

Col. Clibborn, an extensive owner of bog, produced some specimens of peat made as hard as ebony by machinery. After a general discussion the following resolution was adopted:

"That all here present, being most favorably impressed with what we have seen and heard regarding the peat industry, hereby form ourselves into a committee, and undertake to induce our friends and acquaintances interested in this project to attend in Greville Arms Hotel at 12 o'clock on next Friday, 1st October, for the appointment of provisional directors."

Inoculation of Peat. Considerable interest is created amongst agriculturalists by Prof. Bottomley's experiments with bacteriarized peat, as a result of which it is hoped that the home-grown food supply may be largely increased. This remarkable discovery is described by the London correspondent of the Freeman's Journal. Some time ago the professor, who had been lecturing in botany over 20 years at King's College, London, discovered that the plant growth could be wonderfully stimulated by inoculating the soil with the culture of bacteria obtained from the roots of leguminous plants, and in the course of his work discovered that peat was by far the best medium. The results of the treatment are striking. In many cases the size of plants has been doubled and even trebled. Seventy-two cucumbers, weighing a pound each, have been cut from 18 treated plants after a 20-day growth, and sold at Covent Garden before those grown in the ordinary way were ready to be cut; and there are similar instances with regard to other vegetables. The professor considers that if his discovery is taken up and organized on a sufficiently large and authoritative basis home-grown crops of all kinds would reap an immense benefit. "Incidentally," he says, "it would give Ireland a new industry, for, with its practically inexhaustible supplies of peat, the country could provide all that would be required for the whole of the rest of the United King-

dom. I am told of one bog alone of 800 acres, where the annual charge is only £20, from which as much peat as one wanted could be obtained. Besides the value of peat that has been shown by these experiments, there is the fact that ordinary stable manure has been trebled in price in the last two years, and it is difficult to obtain." The Government officials are seemingly alive to the importance of the discovery, for they have made a grant to King's College for the purpose of further investigation.—Irish Industrial Journal, Oct. 9, 1915.

Preparing Peat. International Nitrogen and Power Co., E. A. Buckle and O. D. Lucas. (Br. Pat. 5845, 1914.)

Apparatus for heating pulped peat and the like consists of a chamber inclosing one or more vessels and one or more internally fired water boilers connected to them, the vessels being traversed by tubes conveying the peat, etc. Products of combustion from the boiler flues, which are open ended, fill and heat the chamber and are withdrawn by fans in upper flues, dampers being operated by levers. Preferably, two superposed vessels are mounted above two gas-fired boilers of less than half the length, one at each end, three such sets being arranged in the same chamber. Flow and return pipes connect the boilers to the vessels, which are connected in the middle. The peat tubes are preferably illiptical and are looped within the vessels in which they are supported by frames having small wheels resting upon rails.

Peat Supply in Winter. T. Rigby, N. Testrup and Wet Carbonizing, Ltd. (Br. Pat. 5853, 1914.)

A peat-heating apparatus is supplied in winter from one or more reservoirs near the plant, filled in summer, and worked by the bog excavator. Hot waste liquor from the plant may be discharged into the reservoir near the excavator, to counteract freezing. Preferably the reservoir is connected by a cutting with the excavation in the bog, so that fresh peat can be transferred in barges without pulping.

Peat Briquets That Hold Their Form. Georg Wihtol (Germ. Pat. 287,016, Mar. 15, 1913.)

Peat moor in small pieces is mixed with peat of an older formation, with the addition of a water-soluble binder, for instance sulphite liquor, which makes the briquet proof against moist climatic conditions. It is also claimed that the briquet holds its form until the fire has practically consumed it.

Artificial Stone From Peat Litter. Karl Narr, (Germ. Pat. 286,082, Jan. 17, 1913.)

Before the peat is worked into litter it is passed through a freezing process. Before the litter is formed it is moistened and mixed with a binder, like cement, etc. Blocks formed by this process are claimed not to crumble by drying nor to spawl by the absorption of moisture, but to be permanent in shape. They can be used as insulating material and in building where cork blocks have been used hitherto.

Building Blocks From Peat. Wilhelm Schuetz, (German Pat. 287,704, June 4, 1914.)

The peat is first partly dehydrated by pressing, then rubbed to a fine mass and mixed with a binder, for instance, cement, lime, gypsum, etc.; it is then formed, and dried in the air. The inventor claims that by pressing out part of the water, not only is the water driven out but also those substances detrimental to the binding of the peat block. After 6 to 8 hours the blocks are set and ready for use. Such blocks, he states, are strong and weather proof, and are only half as heavy as ordinary building blocks. Solid, hollow, or decorative stone can be made in this manner.

Dehydrating Peat by Using Addition Products. Nasspress Gesellschaft. (German Pat. 287,470, Jan. 3, 1914.)

Raw peat is passed through mechanical cutters, where without any pressing effect it is cut into granular pieces; it is then passed onto a transmission band which is already supplied with the addition product, for instance, dried granular peat. The transmision band takes the wet and dry granules to a shute which feeds into a drum mixer, so arranged that no pressing effect occurs in the mixer. After the mixing the material is led to a press and dewatered. The inventor's claim that by this means the pressing time is lessened at least 66 per cent. and further that a much larger quantity of water can be expelled by this method The finished product, it is claimed, can be easily briqueted and the product is similar to lignite.

Drying Raw Peat. H. Brune and H. Horst, Assignors to Nasspress Ges. (U. S. Pat. 1,143,497, June 15, 1915.)

Same as German Patent 287,470, abstracted above.

Wood Alcohol From Peat Producer Gas. German Patent Application 45,073—Class 26-d, May 8, 1914.

The Wet Carbonizing Co., Ltd., of London, have applied for a patent process to recover methyl alcohol from peat producer gas by using cooling water direct which has a temperature of 65° C., which condenses the largest part of the steam present in the gas, and then further cooling the steam-free gas by indirect condensers, for instance, in a tube condenser, whereby the wood alcohol condenses.

The process covers producer gas generated in an ordinary gas producer with preheated air and steam, and consists specifically in the cooling of the gas in steps, whereby the largest part of the steam in the gas is taken up in the cooling water of 65° C., whence the gases are further cooled by surface condensation to the ordinary temperature thus liquifying the wood alcohol.

According to the present process the gases from the producer must be cooled to separate the water vapor before they can be used for heating or power purposes. This usually takes place by washing the gases with water, until atmospheric temperature has been reached, whereby soluble parts of the gases, as methyl alcohol, go into solution in the cooling water. These extreme dilute solutions of methyl alcohol prevent the commercial recovery of this product.

The purpose of this process is to prevent the loss of valuable products where possible, which is accomplished by bringing the generator gas containing these condensible products only into contact with water above 65° C., after which the gases are further cooled indirectly in some known surface condenser, whereby methyl alcohol and similar low-boiling products are separated from the gas. The method shows for the first time a possibility of commercially separating wood alcohol from peat producer gas.

Briquetting Peat Dust. Emil Schimansky, German Patent 287,157, 1913. The peat dust, formed in an ordinary peat-briquetting plant, which itself cannot be briquetted, is mixed intimately, after being dried, with dry sawdust and introduced into the briquetting press. Just previous to entering the press it is subjected to an atmosphere of dry steam and then quickly put under a pressure of 1,200 to 1,500 atmospheres in the press.

Preparing Peat. O. A. Ford and J. C. Long (British Patent 7,593, 1914.) An apparatus for drying peat in furnace gases preparatory to grinding and molding comprises an elongated drum

with continuous feeding and discharging means and with means for delivering the gases partly into the drum at the exit end, and partly into an annular jacket, in proportions controlled preferably by a thermostat which operates various dampers. A partial vacuum may be maintained in the drum, and volatile products recovered. In the form shown, the drum is inclined and rotary, having an internal helical rib for advancing the material; this is fed downwards from a hopper, in which it forms a seal, by an agitator and a short band conveyor. Gases from a furnace are led first through the pipes of a steam generator for driving the pumps of the condensing plant, referred to below, and are thus cooled before meeting the peat, the drying temperature being about 100° C. A thermostat for controlling the supply of the gases may comprise a metal tube closed at one end, where it is attached to an internal rod of a more expansible material; the rod operates dampers for checking the supply and for diverting excess into a jacket which forms part of the drum; the thermostat, by a chain connection, also controls a damper in a subsidiary chimney through which the gases can, if necessary, be discharged before reaching the drum. At the top of the drum is a flue which leads the escaping gases and vapors to the main chimney but can be closed wholly or partly so that they pass to a condenser through a closable inlet containing an exhaust fan. This fan creates a partial vacuum in the drying drum, enabling the temperature to be kept low and facilitating the evolution of oily vapors. The condensate collects in a vessel and is pumped to a storage tank; uncondensed gases are delivered by a pump into the chimney or a gasometer. From the drying drum, the peat is discharged to a grinder and thence to the hopper of a molding-press.

Gasifying Peat. T. Rigby and Wet Carbonizing, Ltd., (Br. Pat. 16,918, 1914). In gasifying mixtures containing or consisting of peat in different conditions, the moisture content of the mixture is maintained approximately constant by controlling the proportions of the constituents of the mixture. In the apparatus shown, press cakes of wet-carbonized peat are fed through a rotary screen to a hopper provided with a plate adjustable at any height over a jigging conveyor for varying the quantity delivered per stroke. The material from the conveyor passes by way of a second screen conveyor and hopper to a conveyor. Peat briquets are fed through a hopper provided with a vertically adjustable plate to a jigging conveyor, and thence through a screen to the hopper and conveyor which conveys the mixed charge to the producer. The conveyors may be mechanically or electrically interconnected. Excess material from the hopper and under-

size from the screens pass to disintegrators to be subsequently briquetted.

Ammonia from Peat. B. F. Halvorsen, (Br. Pat. 17,882, 1914.)

According to the invention, an acid or a salt is added to the raw peat, the same heated to a temperature of 160° to 300° C., under pressure, the liquid pressed off, and the ammonia recovered from the latter. The presence of the acid or salt causes, in conjunction with the high temperature of heating, the amount of ammoniacal substances passing into the liquor to increase. The amount of acid or salt to be added varies from about 0.1 to 5 per cent .of the weight of wet peat. In carrying out the process, the solution is still acid after boiling, so that the acid formed during the process (organic acid) or the acid added keeps the ammonia formed bound. Crude peat (preferably with a high proportion of nitrogen) is partly deprived of water, for instance, by cutting up and placing it for drying on the moor, or it is brought directly into the works. Here a small quantity of that acid or salt, which is the cheapest on the spot compared to its effect, is added. The whole mass is then heated under pressure to temperatures which, according to circumstances, vary between 160° and 300° C. For instance, in experiments with a crude peat with 17 per cent. dry substance and 1.27 per cent. nitrogen in the dry substance, the following quantities (in per cent.) of the total nitrogen were obtained as ammonia:

	At 200° C.	At 220° C.	At 240° C.	At 260° C.
Without addition of acid.......	9.1	7.8	19.5	17.8
Without addition of HCl to the extent of 0.93 per cent. of the weight of wet peat..........	30.5	53.8	51.9	56.7

With 16.4 per cent sulphurous acid, added as 2.55 normal solution, on heating to 260° C., 80.7 per cent of the whole quantity of nitrogen was converted into ammonia. With 2.5 per cent "kainite" at 240° C., 50.3 per cent was converted into ammonia. The heating can be carried out in pressure vessels or in tubular systems, as in the Ekenberg process. The ammonia liquid formed is pressed off from the peat, which is then washed, and can be treated alone for fuel. The liquid pressed off is distilled with lime (or some other base) in column apparatus, and the ammonia distilled off is collected as ammonia water or in acids (such as sulphuric acid or nitric acid). In some cases it may also be preferable to use slightly dried peat and a large quantity of

acid, which is then repeatedly utilized for the treatment of fresh quantities of peat, only part of the water being then evaporated between successive operations.

Preparing Peat. T. Rigby and Wet Carbonizing, Ltd., (Br. Pat. 18,030, 1914.) In a process for heating peat, with or without the use of acids or other auxiliary means, and subsequently removing water, the latter operation is effected in filter presses at temperatures of 60° C. and over, and part of the hot effluent is mixed with raw peat, from which some of the natural water may be first removed by draining, air drying, or pressing. The percentages of water before and after addition of the effluent may be 85 and 94 to 95 respectively. The apparatus shown consists of a preliminary band press discharging into a hopper, whence a piston forces the peat through a flap valve into a mixer. A pump delivers effluent into the top of the mixer, from the bottom of which the peat is discharged into a pipe and there treated with steam. The peat then enters a second mixer. Both mixers are provided with rotary and stationary arms designed to avoid pulping, so that less heating is required. According to the specifications, the hot peat or effluent may be partly cooled before addition of the effluent to raw peat; and the peat may be preheated without mixture by part of the effluent before addition of the remainder.

Bacterized Peat. W. B. Bottomley, (Br. Pat. 20,789, 1914). Prof. W. B. Bottomley of King's College, has been granted a patent for a process for the manufacture of a manure by mixing peat with an insoluble phosphate, such as a finely subdivided rock phosphate, bone ash, or bone meal, and causing certain aerobic micro-organisms to grow in the mixture, with the result that soluble humates, readily available nitrogen, and a soluble form of phosphate are produced in the mass. All these are valuable manurial constituents, and there appears to be the additional advantage that the soluble humates present form adsorption compounds with the soluble phosphates, thus conducing to the availability of the manure as plant food. The micro-organisms may be obtained by permitting a solution of some organic matter such as gelatin or meat extract to putrefy, preferably at a temperature of about 30° C. It is easy to prepare a pure culture of the active organism or organisms which determine the required changes, but this is not necessary.

For example, a manure may be made by mixing one part of bone meal with four parts of finely divided peat, moistening the mixture with an aqueous solution of 1 per cent strength of gela-

tin or meat extract, which solution has been allowed to putrefy, and maintaining the mass at a temperature of about 30° C., such as by heaping it on a floor heated by hot pipes. In the course of a week or two the particles of bone meal will have disappeared, and the insoluble calcium phosphate thereof will have become disseminated through the mass in a form soluble in ammonium citrate solution. It is preferable to sterilize the manure by any well-known method before it is used, for reasons now generally recognized in connection with the sterilization of soils.

Instead of definitely inoculating the mass with the micro-organisms, reliance may be placed on the adventitious introduction of suitable micro-organisms from the atmosphere, but the process then becomes somewhat uncertain and of longer duration.

A mineral phosphate may be substituted for bone meal in the foregoing process; it is not, however, so readily attacked.

Distillation of Peat. T. Rigby (U. S. Pat. 1,143,319, June 15, 1915). Primary distillation and decarbonization are carried out in separate, successive steps, the gases from the former being passed through a condensing coil for recovery of waxy substances produced by the distillation, whereas the gases from the decarbonization of the solid residue of distillation are separately treated for the recovery of NH_3. A wax yield of 8 per cent may be obtained by distilling for 50 minutes at 500°.

Briquetting Peat. M. Ekenberg, (U. S. Pat. 1,143,951, June 22, 1915). Fuel briquets from peat are made by heating the wet, raw peat under pressure to about 150 to 250°, drying the wet carbonized peat at 100 to 120° until it contains at most only about 2 per cent H_2O, heating to above 120° to increase its binding properties, and molding under pressure.

Peat Fuel. T. Rigby and N. Testrup, (U. S. Pat. 1,144,250, June 22, 1915). The peat is filtered, pressed, partly pulverized, and further dried while suspended in hot gaseous products of combustion of gas generated by the gasification of part of the peat. A part of the peat used to supply the gas is formed into briquets before gasification and the combustion of the gas is used to generate power in an internal-combustion engine, the exhaust gases from which are used for drying the peat.

Distillation of Peat. Ellis Bartholomew, (U. S. Pat. 1,156,-387, Oct. 12, 1915). In order to extract valuable ingredients from peat and produce coke, a distillation apparatus has been patented by Ellis Bartholomew, of Toledo, Ohio, (assigned to the National Peat Refining Co., Cleveland, Ohio). In this apparatus peat is fed from a closed bin by a screw conveyor to a cylinder called a separator. The bottom of this separator is made hopper-shape and directs the peat onto a grate of electrically heated resistance bars. The heat of the bars drives off the gases from the peat, converting it into coke. The gases pass up and out through openings and the coke is shaken through the grate by suitable means, dropping into another conveyor, whence it is led to a bin. The separator and the peat bin are kept full of the gas from the peat, so as to exclude air. For this purpose a reservoir of the gas is connected to a valve. The gases that pass out are passed through suitable condensers, where the lighter and heavier liquids are obtained.

OBITUARY.

William H. Bowker, one of the best informed and best loved men connected with the fertilizer trade, passed away in Boston on January 4, last.

Mr. Bowker was sixty-five years of age and for forty-three years had been actively at work in the commercial fertilizer industry. He worked not only for his own gain but also for the good of the whole industry, being conversant with every detail of the manufacturing and selling of fertilizer products. The fertilizer industry has lost a big man. The loss of his work and personality will be long felt.

William B. Ruggles, President and founder of the Ruggles-Coles Engineering Co. and member of the Executive Committee of the American Peat Society, passed away at his home in Bergen Point, N. J., on January 22, 1916. He died of pneumonia at the age of 55. Among other inventions he was especially noted for the invention of the Ruggles-Coles double-shell dryer.

LATE NOTICE.

As this copy is being printed we are in receipt of the regrettable news of Professor Davis' death. He died on Sunday evening, April 9th, and his body will be buried at his birthplace—Portsmouth, N. H.

Journal of the American Peat Society

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CHARLES ALBERT DAVIS

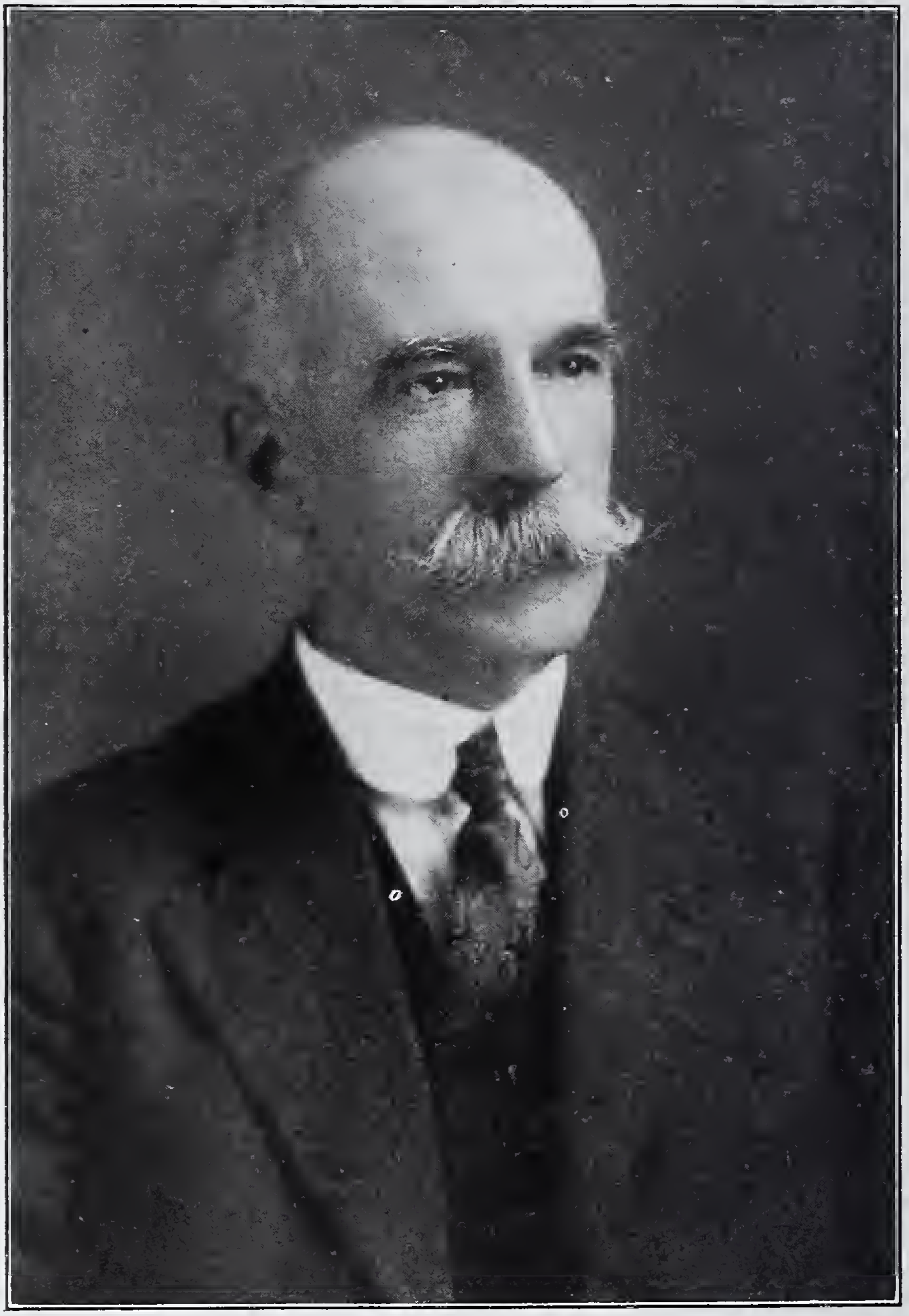
A Biographical Sketch

BY HERBERT PHILIPP

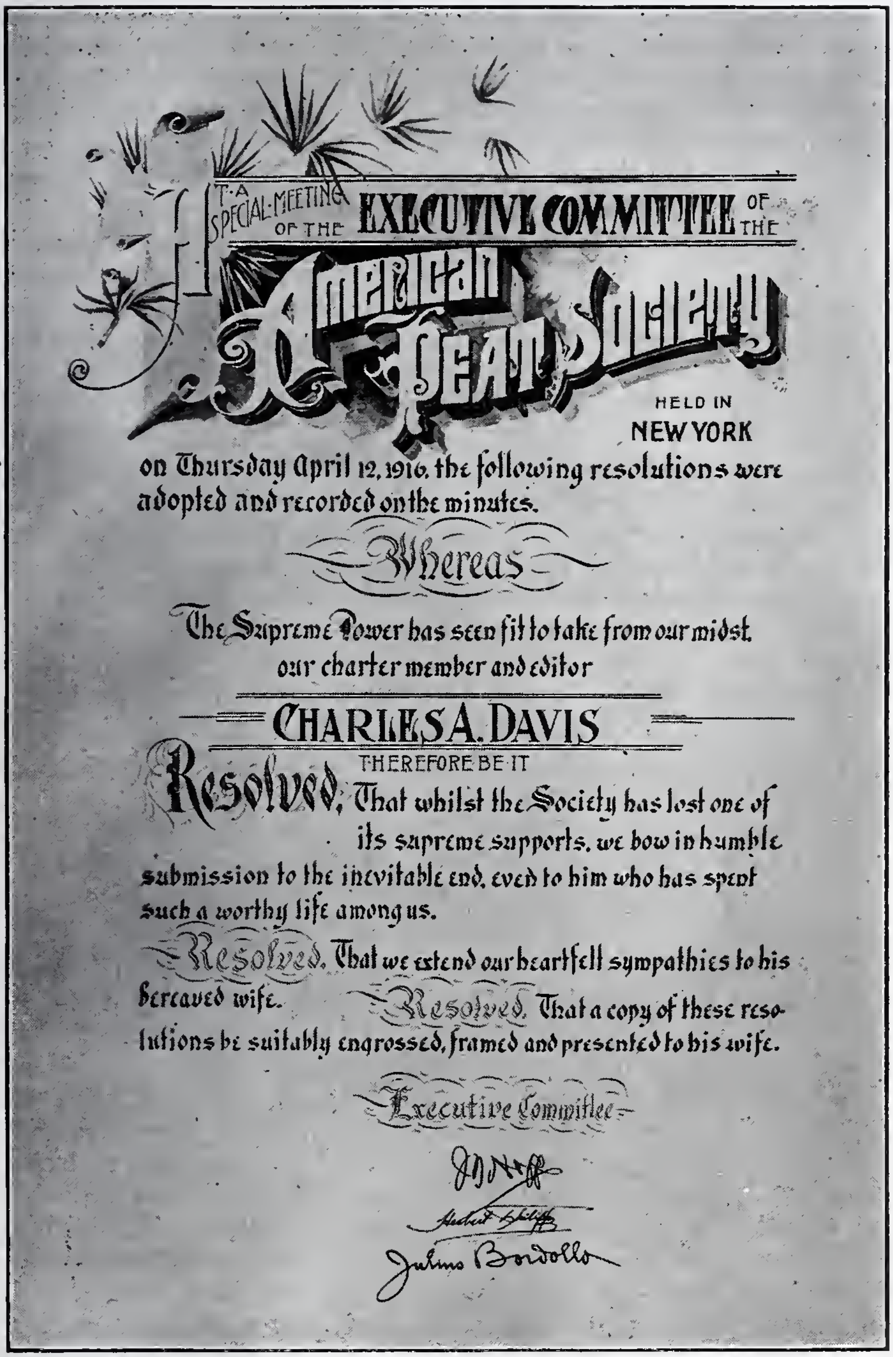
When our last issue was being printed we received the sad news of Prof. Davis' death. Our Society has lost a valuable member and all of us have one real friend less. He had been ailing for some time but we had hopes that he was recovering and did not feel pessimistic until shortly before his death, when we were advised that he had passed into a state of coma.

Charles A. Davis was born at Portsmouth, N. H., in 1861. He received his early education in that city, passing from the high school to Bowdoin College. He made his own way through college, doing whatever job might come along, with no thought of anything being too menial as long as it was honorable. He did not suffer any of those foolish notions of so-called pride, and his associates respected him all the more for it. Everyone who has come in contact with him has entertained a profound respect for him and he was one of those few who has enjoyed other people's respect since an early age. His personality, his calmness in giving advice, his ever readiness to help the weak, together with his uprightness, honesty of purpose and conscientiousness were the factors in his make-up that created for him a large number of friends and a host of respectful acquaintances, which extended even to those who knew him only through correspondence.

After obtaining his degrees at Bowdoin College he pursued his studies further at Cornell and Michigan University, receiving his A. M. degree at Bowdoin in 1889; later he received his Ph. D. at Michigan University. He was professor of natural science at Alma College, Michigan, 1887 to 1896, and professor



CHARLES ALBERT DAVIS



At a Special Meeting of the Executive Committee of the American Peat Society held in New York on Thursday April 12, 1916, the following resolutions were adopted and recorded on the minutes.

Whereas

The Supreme Power has seen fit to take from our midst our charter member and editor

CHARLES A. DAVIS

therefore be it

Resolved, That whilst the Society has lost one of its supreme supports, we bow in humble submission to the inevitable end, even to him who has spent such a worthy life among us.

Resolved, That we extend our heartfelt sympathies to his bereaved wife.

Resolved, That a copy of these resolutions be suitably engrossed, framed and presented to his wife.

Executive Committee

[illegible]

[illegible]

Julius Bordollo

Engraved by W. J. Trainer, Perth Amboy, N J

of biology and geology, 1896 to 1900. He became instructor in forestry at Michigan University in 1901, and in 1905 to 1907 served as curator herbarium. He had already become field agent of the Michigan Geological Survey in 1896, remaining on their staff till 1907, although in 1904 he became a field assistant with the U. S. Geological Survey. In 1907 he became peat expert of the Survey, and in 1910, when the U. S. Bureau of Mines was formed, he was transferred there as fuel technologist and peat expert, where he remained until his end.

Prof. Davis married Frances M. Humphreys, of Brunswick, Me., in 1886. His wife took an active interest in his professional career and assisted him in every way possible. He was a member of a large number of societies, among them being, Phi Beta Kappa, Alpha Delta Phi, American Geological Society, American Association, Michigan Academy of Science, Association of American Geologists, National Geological Society, Washington Academy, Washington Geological Society, Washington Biological Society, Washington Botanical Society, and Cosmos Club, honorary member of the Canadian Peat Society, correspondence member of the New England Botanical Club, and honorary and charter member of the American Peat Society.

Prof. Davis' publications were also numerous, being as follows:

Wells and Water Supplies in Saginaw Drainage Basin.

Peat Deposits of Maine: Bul. 376, U. S. Geol. Surv.

Uses of Peat for Fuel and Other Purposes: Bul. 16, U. S. Bureau of Mines.

Natural History of Marl: Jour. of Geology, 1901.

Peat in Michigan: Ann. Rept. Mich. Geol. Surv., 1907.

Salt Marsh Formation in Vicinity of Boston, Mass., and Geological Significance: Economic Geology, 1910.

Our members are all familiar with his many contributions to our Journal, of which he has been editor since its inception. Prof. Davis is perhaps best known to us and the peaters of the world by publication of "Peat in Michigan," which is published in book form and represents one of the best works on peat that existed in the English language at the time of its publication.

Charles A. Davis represented one of the greatest all round naturalists in this country; he was well versed in biology, botany, chemistry, conchology, entomology, geology, herpetology, ichthyology, mineralogy, mycology, vology, ornithology, and zoology. In rambling through the woodlands and meadows he could classify at a glance any rock, bird, insect, animal, or plant.

In recent times Prof. Davis had been engaged in investigations and research work on the subsidence of the Atlantic Coast, and has made some wonderful discoveries of the fossils

in the oil shales; his work may mean a great deal that was unsuspected in regard to the origin of petroleum. A prominent botanist recently stated that Prof. Davis had added to the science of botany an entirely new phase which would have to be taken into account in the future. His photographs of the oil shale fossils are possibly the only ones in existence.

Peaters, we have lost a valuable colleague and compatriot; the world has lost a scientist and gentleman.

Russian Peat Industry

By Fr. Lisitzin, Petrograd, Russia, Feb. 20, 1916*

I am going to give you herewith some information regarding the Russian peat industry, which is taken from the work of the Commission Appointed by the Manufacturer's Society to Help and Improve Industry in Moscow.

The carbon found in 409 samples, dried, was 42.11 to 38.67 per cent. However, the largest number of peat samples showed a carbon content between 52 and 54 per cent. Other constituents in dried peat were as follows: H_2 3.20 to 8.97 per cent.; N_2 1.10 to 2.42 per cent.; O_2 30.25 to 36.06 per cent.

The sulphur content was small except in samples from a few places where the water of the bog originated from pyritic territory. The sulphur content in such samples was about 0.12 per cent. The ash content varied considerably, being between 1.05 to 52.69 per cent., but the largest part of the peat (dried) contained 3 to 10 per cent. ash. The distribution of the ash is as follows:—

High moor peat contains 1.05 to 7.52 per cent.

Intermediate moor peat contains 9 to 12 per cent.

Low moor peat contains 6.9 to 36.73 per cent.

It is of interest to note the ash content at different depths of the peat.

Ash Content in High Moor Peat.

1. About 60 c.m. from surface........ 1.10 per cent.
   About 140 c.m. from surface........ 2.20 per cent.
   About 280 c.m. from surface........ 4.50 per cent.
2. About 60 c.m. from surface........ 1.80 per cent.
   About 140 c.m. from surface........ 3.30 per cent.
   About 280 c.m. from surface........ 5.00 per cent.

Analysis by Botscharoff of the Imperial Technical Institute of Moscow:

Depth, meters	High moor peat, per cent	Intermediate peat, per cent	Meadow peat, per cent	Prairie peat, per cent
0.5	4.34	9.60	7.26	8.08
1.0	3.69	7.22	6.24	6.04
1.5	3.04	6.10	4.96	7.00
2.0	3.52	6.41	4.59	4.80
2.5	2.88	6.02	4.43	5.61
3.0	2.96	6.20	4.32	4.42
3.5	3.41	6.02	4.49	4.40
4.0	3.20	6.41	4.43	4.80
4.5	3.52	7.11	5.26	4.00
5.0	3.44	7.22	4.62	6.01
5.5	3.61	7.89	5.05	5.65
6.0	4.62	8.80	9.14	5.60

*Translated by Herbert Philipp.

The moisture in the peat is distributed as follows: In top layers, 89.46 to 89.35 per cent.; at 1.40 meters depth, 90.25 to 83.37 per cent.; at 2.80 meters depth, 88.97 to 83.66 per cent.

The temperature employed to bring peat to a constant weight has an influence on its heat value, as is shown by the following data:

Dried at 100°C., peat has a heat value of 5360 calories.
Dried at 110°C., peat has a heat value of 5026 calories.
Dried at 120°C., peat has a heat value of 4923 calories.
Dried at 130°C., peat has a heat value of 4878 calories.

The longer a peat deposit is worked the greater the weight of the cubic contents (9.7 cubic meters being the Russian unit) of air-dried peat.

Time of working bog, years.	Weight of 9.7 cubic meters of air-dried peat, kilograms.	Description of peat.
2	3290	Low moor, slightly decomposed.
2	2900	Meadow peat.
2	4170—4200	Low moor.
6	4600	High moor.
7	3400	High moor.
9	3600	High moor, slightly decomposed.
10	4600	High moor, well decomposed.
11	4016	High moor, parched and timbered.
14	4340—5000	High moor.
15	3100	Meadow peat.
17	4100	Low moor (timbered).
20	4410—4500	Low moor.
23	4300—4500	High moor.
30	4100—5000	High moor.
35	4230	High moor.
40	4100—4700	High moor.

Start work, 4:00 a. m.
Breakfast, 8:00-9:00 a. m.
Lunch, 12:00-2:00 p. m.
End work, 7:00 p. m.

The following factors influence the production of peat: (1) Kind of machine, (2) quality of the peat, (3) source of power, (4) the number and customs of the workmen.

Forty-five per cent. of the presses in use are the Denis machine. and 32 per cent. of the Anrep type.

Excavators have been tried but on account of the numerous tree roots present their use has been abandoned. Trials have been made to reduce the labor employed by introducing mechanical means (the working period is about 60 days). To pro-

duce 33 to 40 metric tons of air-dried peat per day the following labor is required:

	Transp'n by wagons.	Mech'l transp'n.	Diff.
Men	25	17	—8
Boys	2	5	+3
	27	22	—5

Labor Cost.

25 men	@ $1.56—$39.00		17 men	@ $1.56—$26.52	
2 boys	@ .41—	.82	5 boys	@ .41—	2.05
		$39.82			$28.57

To obtain 4170 kilograms of air-dried peat requires 2.3 to 4.7 Russian units (9.7 cubic meters) of raw peat. The production costs consist of the following items: (1) Sinking fund and depreciation, (2) production costs, (3) drying costs, (4) heating material for the machines, (5) cost of machine operations, (6) administration, medical, insurance, etc., (7) planning and draining the peat bog, (8) various expenses.

	Cents.	Per cent.
1. Depreciation, etc., per 36 lbs......	.47	11.5
2. Production cost	1.30	33.0
3. Drying	.42	10.5
4. Fuel	.10	3.0
5. Engine operation	.52	13.0
6. Administration	.52	13.0
7. Depreciation on plant............	.63	16.0
	3.96	100.0

Peat used to be cheaper. The production in the Moscow district has increased to 350 million pounds and will be further increased.

It is very probable that there will soon be great changes in the peat situation. Trials on a small scale have been very successful and work is now going forward on a large scale.

Some Chemical Aspects of the Peat Problem*

By Gilbert T. Morgan, D Sc., F. R. S., F. I. C., A. R. C. Sc., M. R. I. A. Professor of Chemistry iu the Faculty of Applied Chemistry, Royal College of Science for Ireland

Magnitude of the Problem.

Among the important matters overshadowed by the war is the perennial problem of the economical utilization of peat. Yet the question is one in which the belligerent countries are directly interested inasmuch as peat is found principally in high latitudes. Extensive deposits exist in Great Britain, France, Russia, Italy, Scandinavia, Germany, and Austria. One-seventh of the total area of Ireland is covered by peat and enormous tracts of this deposit are found in Canada. For more than a century the problem has received the attention of numerous scientific investigators and has been attacked from many different points of view.

A Suggested Solution.

Only two years before the outbreak of war a practical solution of the problem was claimed for Germany by Dr. Carl Duisberg, a director of the color factory of F. Bayer & Co., Elberfeld, who at the Congress of Applied Chemistry held in 1912, at New York, stated his case in the following words:

"The latest and most rational method of utilizing the peat or turf beds which are so plentiful in Germany and many other countries is practiced in Schweger Moor near Osnabruck, according to a process discovered by Frank and Caro. There peat gas is produced and utilized and ammonia obtained as a by-product, the required power being generated in a 3,000-horsepower central electric power station. The moorland, after removal of the peat, is rendered serviceable for agricultural purposes.

"At that place nearly 2,500 to 2,600 cubic meters of gas with 1,000 to 1,300 calories were obtain from 1,000 kilograms of absolutely water-free peat in the form of air-dried peat with 45 to 60 or 70 per cent of moisture. This gas represents energy equal to 1,000 horsepower hours, equal to 700 kilowatt hours, after deducting the heat and power used for the operation of the gas works. In addition 35 kilograms of ammonium sulphate was produced from the above quantity of peat, which contains 1 per cent of nitrogen."

The foregoing development appears to be a practical realiza-

*Reprinted from Irish Technical Journal.

tion of the view held by many workers on peat in this country that the most economical use to make of this combustible is to convert it into gaseous fuel in suitable gas producers. Some of the earlier attempts at this solution of the peat problem are summarized in Professor Ryan's comprehensive reports on the Irish peat industries. (Economic Proc. Royal Dublin Soc., 1908, vol. 1, pp. 522-529.)

Other methods of disposing of peat must, however, be taken into account, such as the production of peat litter and peat molassine. Moreover, the recent epoch-making discoveries of Professor W. B. Bottomley (Ann. Botany, 1914, vol. 28, p. 531) on the application in agriculture and horticulture of bacterized peat or "humogen" will, when put into practice on an extended scale, lead to the utilization of large quantities of turf. But nevertheless these outlets for peat will still leave available for fuel enormous quantities of turf, which should preferably be converted into gaseous fuel because by this process it becomes possible to recover certain valuable by-products.

Gaseous Fuel from Peat.

When peat is treated in a gas producer the products are combustible gas, ammonia, ash, tar and an aqueous distillate containing certain technically important organic compounds. The combustible gas, which is comparable in calorific power with that obtained from lignite, consists of carbon monoxide and hydrogen mixed with the noncombustible gases, nitrogen and carbon dioxide. The peat producer gas is generally free from sulphur, the absence of this element being of great advantage in a gaseous fuel used in iron and steel industries and in the manufacture of glass and ceramic wares.

At present the only plant of this description in Ireland is the gas producer furnishing the gaseous fuel for the gas engines of the factory of Messrs. Hamilton Robb, Ltd., of Portadown. It is of interest to note that although on account of the comparatively small capacity of the plant no attempt is made to recover and utilize any by-products, yet, nevertheless, this installation has proved to be a financial success. There can be little doubt that in a scientifically controlled plant, large enough to render practicable the recovery of ammonia and other by-products, the economy effected would be considerably greater.

By-Products from the Peat Gas Producer.

Ammonia.—Peat may contain 0.5 to 2.5 per cent of nitrogen, and in recent years considerable improvements have been made in the way of increasing the yield of ammonium sulphate recoverable from this combined nitrogen.

By passing steam over peat heated to 350° to 550° almost the whole of the nitrogen is obtained as ammonia (Caro, Chem.

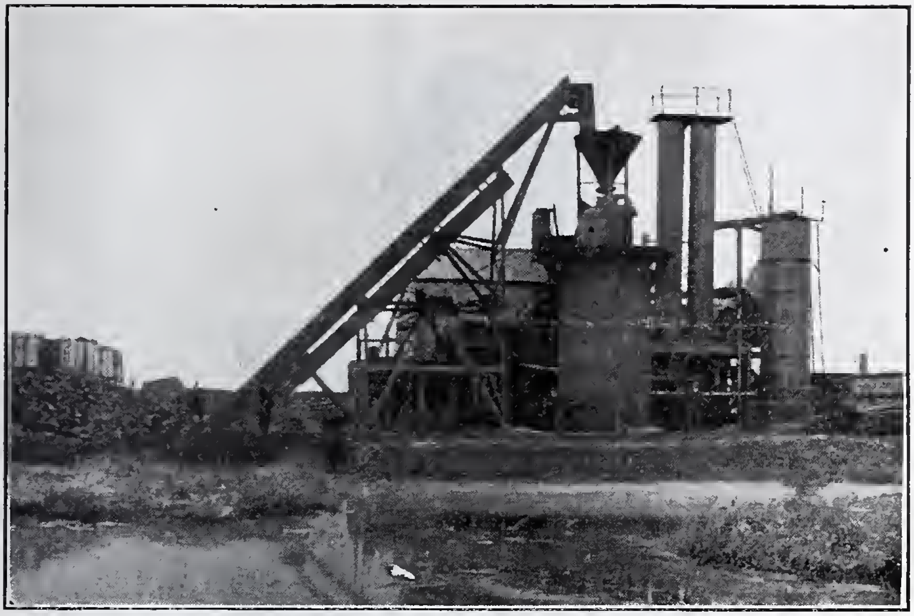


Fig. 1.—The first producer plant in the world making regularly producer gas and ammonium sulphate from wet peat, containing up to 75% of water.

Zeit, 1911, vol. 35, p. 505). With a peat containing 50 to 70 per cent of water and 1.05 per cent nitrogen, Frank, by operating on 50 to 60 tons of wet peat at a time, obtained 90 pounds of ammonium sulphate per ton of peat. This yield corresponds with 77 to 80 per cent of the total nitrogen.

Caro has raised the yield to 85 per cent of the total nitrogen working on peat containing 60 per cent of water.

Similar improvements have been embodied in the modern types of Mond plant so that now it is possible to recover the greater part of the nitrogen of peat in the form of the valuable fertilizer, ammonium sulphate. The other commercial nitrogenous fertilizer is sodium nitrate, a substance also required in the manufacture of nitric acid as a starting point in the production of explosives and synthetic dyes. The importance of increasing the output of ammonium sulphate from peat lies in the circumstance that this salt can displace sodium nitrate as a nitrogenous manure, thus rendering the nitrate available for the manufacture of explosives and other chemical products.

For the four illustrations of producer plant specially designed for the gasification of peat with ammonia recovery I am indebted to the Power-Gas Corporation, Limited, of Stockton-on-Tees. This corporation who, in 1905, first turned their attention to this method of utilizing peat have obtained the extremely favorable results tabulated below:

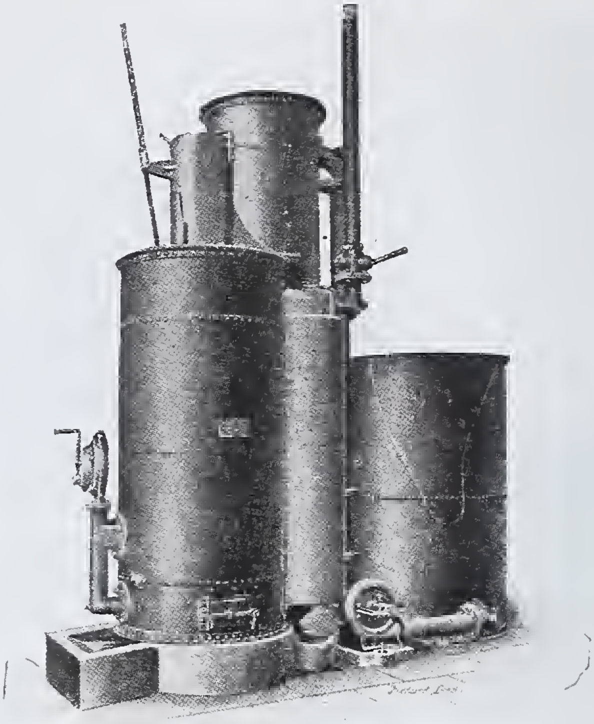


Fig. 2.—Suction pressure semibituminous gas producer. Installed in single units, 20 B.h.p. up to about 400 B.h.p., handling peat containing more than 37% of moisture, and in torves of any size not exceeding 8 by 4 by 4 inches; the truf to be reasonably free from dust.

Fuel used.	German Peat per cent.	Italian Peat per cent.	English Peat per cent.
Moisture content of fuel	40 to 60	15	57.5
Nitrogen content of fuel	1.0	1.58	2.3
Quantity of gas produced per ton of theoretically dry peat	cu. ft. 85,000	cu. ft. 60,000	cu. ft. 90,000
	B.t.u. per c.f.	B.t.u. per c.f.	B.t.u. per c.f.
Heat value of gas produced	150	166	134
Sulphate of ammonia produced per ton of theoretically dry peat	70 lbs.	115 lbs.	215 lbs.

The Simon-Carves By-Product Coke-Oven Construction and Working Company, Limited, have made large-scale experiments on the gasification of peat in Moore gas producers. Very favorable results were obtain, and for the data of a seven days' test on Norfolk peat I am grateful to Mr. J. H. Brown of this company. Peat, containing 63 per cent of moisture and with a nitrogen content of 2.235 per cent, yielded per ton 94,850 cubic feet of gas (100 B.t.u. per cubic foot) and 168 pounds of ammo-

nium sulphate. A longer run would certainly have given even more of this salt.

These experiments confirm the claims made by Dr. Duisberg, and demonstrate conclusively that peat containing a high proportion of moisture can be gasified so as to yield a gas fuel of high caloric value with a good recovery of nitrogen in the form of ammonium sulphate.

Peat Ash.—Peat differs from wood in yielding on combustion a comparatively large and variable proportion of mineral ash, the amount varying from 5 to 15 per cent.

There are very few published anaylses of the ash of peat. A determination of the constituents of the ash of a moss peat from a high moor in the Canton of Zurich, Switzerland, made in 1859 by H. Bohl (Dinglers Journal, vol. 153, p. 223), showed that the ash contained the oxides of aluminum, iron, and calcium, existing to a considerable extent in the form of carbonate, sulphate, silicate, and phosphate. The ash also contained a very appreciable amount of alkalies, with a preponderance of potash.

As the peat ash must consist in part of those mineral constituents of the soil originally assimilated during the growth of the peat vegetation it may fairly be assumed that the ash constituents would act beneficially when restored to the land rendered available for cultivation by the removal of the peat. This applies especially to the potash and phosphate present in the peat ash. By using the peat ash as a dressing for the recovered land the potash locked up in peat would be rendered available for agriculture at a time when the shortage of this alkali is felt very acutely.

Peat-Producer Tar.—The incomplete combustion of peat in the producer leads to the formation of a certain proportion of tar which is collected in the hydraulic scrubbers of the plant. As the result of many trials made at the fuel-testing station at Ottawa it was concluded that the tarry components of the gas evolved in the upper zones of suitable producers could not be entirely burnt or split up into permanent combustible gases. The condensation of a certain amount of tar is unavoidable, and special means of removing this by-product must be adopted.

The amount of tar produced yearly in the Portadown plant is about 100 tons. Samples of this waste product were examined in the chemical laboratories of the Royal College of Science for Ireland, when the results showed that a fractional distillation of the tar resulted in the isolation of substances of industrial importance.

A greatly increased output of the peat tar is, however, the first essential step towards commercial success in this direction.

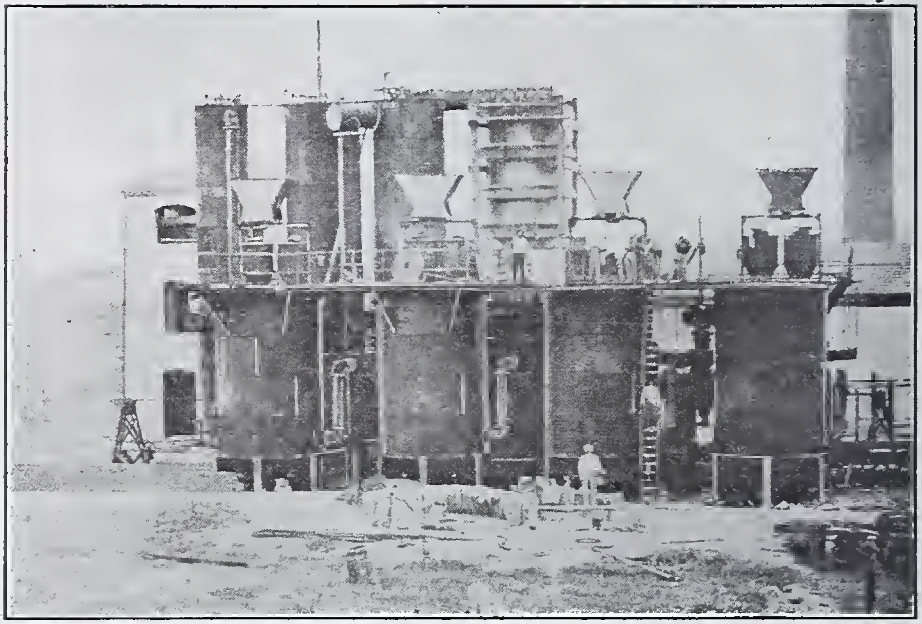


Fig. 3.—Peat power gas plant, with ammonia recovary, designed to gasify about 100 tons per day. In operation at a Central Electric Station, Pontedera, Italy.

This increase would result naturally from the installation of large plants for the gasification of peat or from an increase in the number of factories using gas derived from peat. Ten installations comparable in size with that of Messrs. Hamilton Robb, Ltd., would yield approximately an annual output of 1,000 tons of peat producer tar, a quantity which would furnish a practical basis for the industrial exploitation of the derivatives of this tar.

Many experiments have been made in the distillation of peat and on the fractionation of the resulting peat tars, but the results, which are summarized in Professor Ryan's instructive report, indicate that our knowledge of the chemical nature of the products is far from complete (loc. cit. p. 516, compare Dvorkovitz, Jour. Soc. Chem. Ind., 1894, vol. 17, p. 596). The older distillations were not made under conditions comparable with those obtaining in gas producers, but in spite of this difference the products of the fractional distillation of the respective tars appear to be somewhat similar.

In the experiments carried out by myself and Mr. G. E. Scharff (Economic Proc. Royal Dublin Soc., 1915, vol. 2, pp. 161-167) distillation of the moist crude producer tar effected a separation of certain volatile oils from a nonvolatile bituminous material (crude pitch) amounting to about 17 per cent of the

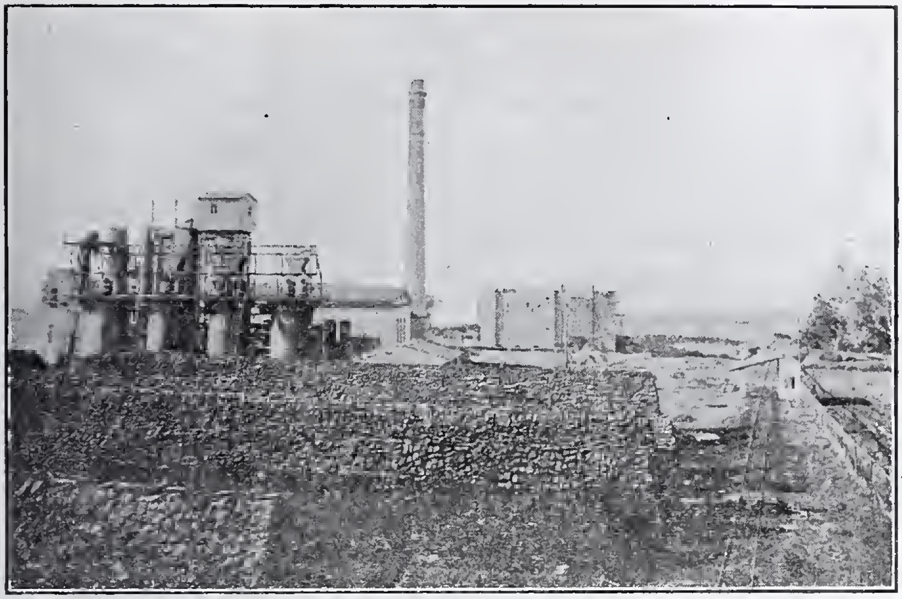


Fig. 4.—The Pontedera installation with peat stacking area in the foreground.

total tar. By heating the crude pitch to 122° C. and pouring off the liquir portion about 6 per cent of a refined soft pitch could be separated from a solid friable carbonaceous residue.

This pitch, either alone or mixed with the carbonaceous matter, could be used as asphalt, as a caulking material or as an insulator in electrical work. The carbonaceous matter could be utilized separately as a self-briquetting combustible of high calorific value.

Volatile Oils from Peat Tar.

The moist peat producer tar contained about 29 per cent of water and yielded on distillation 50 per cent of volatile oils. The latter by further treatment were separated into neutral oils, waxes, and acidic oils.

Acidic Oils.—The last of these fractions was obtained by extracting the crude distillable oils with dilute caustic soda and reprecipitating the acidic oils from the alkaline extract by means of a mineral acid. Fractional distillation of the acidic oils showed that these substances consisted principally of complex phenolic compounds. Attention was specially directed to these substances as they seemed likely to afford material for the manufacture of useful disinfectants comparable in efficiency with lysol, creolin, cyllin, and other coal tar disinfectants.

Peat Disinfectants.

It was formerly known that peat tar contained substances having antiseptic properties, but these compounds had hitherto neither been isolated nor standardized (compare Ryan loc. cit. p. 514; Szek, Eng. Pat. 15606, 1902).

The well-known Rideal-Walker test for disinfectants and the modified procedure devised by Martin and Chick afford methods for controlling quantitatively the separation of the germicidally active acidic oils from peat tar, and for ascertaining the bactericidal value of these acidic oils. Phenol and the cresols are segregated in the fraction boiling below 200° C., which is about seven times as toxic as phenol itself towards Bacillus typhosus. The fraction of acidic peat boiling at 200° to 250° is 17 times as active as phenol (carbolic acid) on the same pathogenic organism.

The most intense germicidal activity is possessed by the fraction of acidic peat boiling at 253° to 360°, for this product has a phenol (carbolic acid) coefficient of 31. (Morgan and Scharff, Eng. Pat. 19,253, 1914.)

These results show that by distillation and simple chemical treatment of the oils obtainable from peat producer tar one can, under appropriate bacteriological control, isolate oils of intense bactericidal activity suitable for the manufacture of antiseptics, disinfectants and germicides. When it is remembered that phenol (carbolic acid), the standard disinfectant of this type, is greatly required in the manufacture of explosives (lyddite), drugs (salicylic acid, aspirin, etc.), as well as for many other synthetic products, it will be readily realized that these peat disinfectants would be welcomed as efficacious substitutes for carbolic acid, if they were forthcoming in sufficient amount, especially at the present time when antiseptics are so urgently needed.

These fractionated germicidal oils can be employed either severally or in varying combinations in the manufacture of antiseptics, disinfectants, and germicides. For this purpose they may be used either in a concentrated form or diluted with organic solvents. These oils are sparingly soluble in water and can be used in suspension in this medium. They can also be employed in emulsified condition, the emulsification being produced by their intimate mixture with gum acacia mucilage, castor oil soap, or other well-known emulsificants.

These germicidal oils can also be made up into solid disinfectants by mixing with hard soap, cane sugar, milk sugar, dextrine, starch, gums, resins, or with porous materials such as fuller's earth, infusorial earth, gypsum, powdered chalk, or

whiting, slaked lime, animal charcoal, wood charcoal, or other absorbents.

Neutral Oils from Peat Tar.

The neutral oils left after extracting the germicidal acidic oils with alkali were purified by fractionation when the lower fractions were obtained as clear pale yellow liquids darkening rapidly on exposure to the atmosphere until they become dark brown and almost opaque. During this process the oils absorb a considerable proportion of atmospheric oxygen.

The foregoing neutral oils could be used as lubricants, as liquid fuel, for example, in Diesel engines, and when mixed with the pitch from peat tar would furnish a refined tar.

The chemical reactivity of these neutral (nonacidic) oils shows that they do not consist wholly of members of the paraffin series. Their exact relationship to other hydrocarbon series is not known with certainty and they would certainly repay further investigation.

Wax from Peat Tar.

The higher fractions of the neutral oils boiling above 250° C. deposit on cooling considerable quantities of crystalline solid. This material, when drained and dried, is an almost colorless wax melting at 35° to 40° C., and would serve as a promising starting point for the manufacture of candles.

Aqueous Distillate from Peat Tar.

The aqueous distillate from the producer contains in addition to ammonia certain organic substances soluble in water, among which have been recognized methyl alcohol, acetone, acetic acid and its immediate homologues, and pyridine bases. All these compounds are of industrial importance. Methyl alcohol is an important solvent and the starting point for formaldehyde. Acetic acid and its homologues are required for the manufacture of acetone and other ketones. Acetone is an important solvent used in considerable quantities in the manufacture of the explosive, cordite. The pyridine bases are pungent liquids useful both as solvents and as disinfectants. The recovery of these compounds could be rendered practicable by suitably modifying the condensers and scrubbers of the peat producing plant.

SUMMARY.

1. Peat has long been employed as a domestic fuel. Its industrialization could be most efficiently brought about by gasifying it in gas producers, as this procedure would render

feasible the recovery of several valuable by-products.

2. The combined nitrogen of the peat can be economically recovered in the form of ammonium sulphate. This valuable fertilizer, together with the peat ash containing potash and phosphoric acid, could be restored to the land from which the peat has been taken.

3. Peat tar, another by-product, can be fractionated into the following useful materials: refined pitch and tar, candle wax, lubricating and burning oils, and very powerful disinfectants, greatly exceeding carbolic acid in germicidal strength.

4. The aqueous distillate from the producer contains methyl alcohol, acetone, pyridine bases and crude acetic acid, all of which are capable of recovery and utilization.

The economical utilization of peat in the generation of gaseous fuel, even without recovery of by-products, is to-day an accomplished fact. It can scarcely be doubted that, with efficient chemical control, a larger plant of sufficient capacity to deal rationally with the ammonia, tar, and other products of the destructive distillation of peat would lead to still greater economies in the employment of this important combustible.

Jameson-Wet Carbonizing, Ltd. Patent Lawsuit

Abstracted from Illustrated Official Journal by Herbert Philipp

This lawsuit took place in England about a year ago, the details having now come to hand. The patent involved (Br. Pat. 10,370) was issued to J. E. Jameson, O. H. Valpy, and E. A. Buckle on May 1, 1912, and was entitled "Treatment for Extracting Water from Peat and the Like." The process consisted of passing an electric current through a pulp of disintegrated material at 100° to 120° C., under a pressure of about 10 atmospheres. It is claimed that the hydrocellulose of the peat is decomposed, the pulp being thus rendered amenable to rapid filtration under slight pressure. In 1914 the Wet Carbonizing, Ltd., presented a petition for the revocation of the patent. The petition was dismissed and an appeal was taken, the appeal being also dismissed about the middle of 1915.

Much of the discussion furnished material that should be useful to many of our readers who are interested in dewatering peat. To get a clear idea on what the discussion was based we reproduce a part of the specifications of the patent, as follows:

"This invention relates to the treatment of peat and the like whereby it is freed from its natural water. It is known that when peat in an admixture with water is heated to a temperature of 180° to 200° C. under a pressure of 20 to 25 atmospheres, the natural water of the peat is rendered expressible without any substantial decomposition of the peat taking place, and it has already been proposed to effect such heating in partly heated tubes, where the substance is carried forward continuously under pressure and under circumstances which effect a transfer of heat from the heated substance to the cool substances entering. It has also been proposed with a like object to subject peat to electro-osmosis in one instance under slight pressure and in another case at a temperature above the normal.

The present invention is based upon investigations carried out with a view to ascertaining the most favorable conditions for the treatment of peat with a view to rendering its natural water expressible without any material decomposition of the peat. Such investigations have demonstrated that at temperatures below 85° C. peat is so bad a conductor that no electro-osmotic process can be advantageously applied. At 85° C.,

however, the peat is conductive and if a current is passed for a sufficiently prolonged period, the desired change in the peat ensues with more or less completeness.

According to the present invention an electric current is passed through peat heated to a temperature of at least 100° C., under a pressure sufficient to prevent the formation of steam. The electric current may be continuous or alternating but a continuous current is preferred, as with it in general a lower temperature suffices than is required with an alternating current to produce as good result. The voltage may vary within wide limits but a voltage of about 200 has been found to be on the whole the most economical. As stated above, the temperature is at least 100° C. and the range of 100° to 120° C. with a pressure of about 10 atmospheres is preferred, but much higher temperatures with correspondingly increased pressure may be used. If the temperature exceeds 150° C., which is the lowest at which it is believed the hydrocellulose of peat is decomposed by heating peat with water under pressure without the passage of electric current, the electric current so accelerates the decomposition as to make the process economically advantageous as compared with the case where other conditions being the same no current is employed."

The Wet Carbonizing, Ltd., raised the following objections:

(1) The patentees were not the true and first inventors of the alleged invention. It was not alleged that any person was the true and first inventor; (2) the alleged invention was not proper subject matter for a patent by reason of the common knowledge; (3) the alleged invention was not useful; (4) the alleged invention had been published.

The Wet Carbonizing, Ltd., had seemingly carried on some experiments and were unable to work the patent. They also referred to publications by Ekenberg, who took out the basic patents for his opinion as to the wet carbonizing process. They also stated that Ekenberg had tried the electric current and had not obtained the desired results, but the patentees claimed that they had done what Ekenberg had failed to do. The Wet Carbonizing, Ltd., argument is offered here in abstract form.

Ekenberg's paper shows that there is rapid decomposition taking place under the action of the heat, that is, wet carbonizing. Peat sometimes contains 92 per cent of water. Heating was thought to be too expensive, and other methods, such as chemical methods and pressing, were tried, but without success. There is no point in the mention of 85° C.—the electric conductivity does not reach a maximum at that temperature, as the temperature rises, the conductivity increases. Experiments at voltages varying from 200 to 34 show that no useful results

are obtained. The essential condition, as stated by the patentees, is that there shall be a small quantity of electricity passing through the peat. There is not a word in the specification about the current required. The patentees said that they were going to do what Ekenberg had failed to do. The respondents read the direction as to current as saying that one must not use electricity at such a pressure that it will generate heat. They have not put forward a single experiment that is comparative; in all, the results are due to increased heat and prolonged heating. There is no change at 85° C., or only the ordinary gradual change. One may raise the temperature as much as Ekenberg did, and still find that heat will be advantageous. If it were true that, the moment one decomposes the hydrocellulose, no more electricity will pass, the patent would be valid. There is no direction to act, not by heat, but by electricity. It is admitted that if electricity is used so as to produce heat, the process is of no value. The idea that heating by electricity would do any harm never entered the heads of any of the scientific witnesses. Their criticism of the appellants' experiments is that so much electricity has been allowed to pass that it has caused heating. Some of their witnesses said that the essence is low voltage, others said low density; their experiment shows simply that the whole thing is as Ekenberg said, moonshine.

As to the appellants' apparatus, the only objection taken is that they use too high a voltage and pass too much current through it. This apparatus was made in accordance with the specification. In the appellants' experiments there was a great rise of temperature, which the respondents failed to account for; it is accounted for by the absence of insulation. Using Ekenberg's process and heating to 180°, a better result was obtained than by using the patented process. The respondents took much longer to obtain their results with electricity alone than with heat alone. They had no means of measuring the amount of water coming out. They say the process goes on too rapidly with the non-heat treatment, and they take the time when the process is the same, not that in which the water is flowing freely. The Petitioners say that is fallacious. Their experiments are valueless for the purpose of showing that electricity has any effect. They do not cavil at the appellants' experiments, except by saying that the appellants used too high a voltage, and heated; but if it is true that the decomposition of the hydrocellulose stops the current there can be no danger of overheating. As to the sufficiency of the specification, there is no direction, except to try electricity until one succeeds. The invention is for the use of electricity, or, as the respondents say, a certain current of electricity. A specification that consists merely of suggestions

is bad. The evidence shows that there are no sufficient directions. They found no immediate change of conductivity on the decomposition of the hydrocellulose and they said there is no proof that electricity has any effect at all. The witnesses said there is no proper description, and there are only diagrammatic drawings. There are no data in the specification to show how much of the electricity is to go as heat. There ought to have been definite instructions. If it were true that the decomposition of the hydrocellulose has the effect that it is said to have, the directions given would have been good working instructions. No practical plant has been made except the demonstration plant. The judgment of the court below involves a misinterpretation of the specification with regard to the warning said to be given as to the current to be used. The petitioners have obtained no good results with their process. If they could get the results at 70° C., instead of at 120° C., there would be good subject matter. Ekenberg got down to 68 per cent moisture.

If the product obtained by the use of electricity is no better than that obtained by heat, but is cheaper, there would be subject matter for a valid patent. The patentees admit that the application of electricity to peat is not new. The petitioners say that the patentees have not disclosed the conditions that are necessary for the success of the process. Ekenberg had succeeded in rendering the water expressible without the decomposition of the peat. The patentees thought there was a body, hydrocellulose, that was responsible for holding the water, and that that body was decomposed by electricity. If that were so, there would be a limited voltage required to destroy the body, and the patentees thought 200 was the lowest voltage that would suffice, and that when that voltage was reached, there set in a rapid and complete disintegration of the peat, including the hydrocellulose. They thought that that body caused the electric conductivity of peat, and that up to a certain point the current did not heat the peat because it was expending itself on decomposition. Ekenberg said the object could be attained by electricity at a certain temperature. The petitioners say that the direction means that one is to work the process so that one does not get heat; it does not mean that one is to work with a low voltage.

No one needs to be warned against using excessive heat, it is wasteful. The petitioners have fairly carried out their experiments, and they have failed. The specification is inconsistent with heat doing any harm; the absence of a warning against heat makes the document consistent. Decomposition is the only purpose the electricity is serving; the decomposition absorbs the heat. The direction was inserted to say that peat is conductive

only because of the hydrocellulose. The respondents have to get over the statement that the voltage may vary within wide limits, but 200 is preferred. It is unfortunate for the patentees that they happened to have an apparatus in which they were using 200 volts, and they put that figure into the document. Often the knowledge of a patentee is not complete. The claim is not limited as regards the higher temperature, but the proper view is that it does not extend above 180° C., nor under 150° C. The decomposition of hydrocellulose was mentioned by Ekenberg, who had made a series of investigations as to what it was that retained the water in peat, and had fixed a temperature near 100° C. as being that which had to be reached.

The decomposition can be effected at a lower temperature than Ekenberg said, if, at the same time, electricity is used. Several passages of the specification are consistent with that view. If the lower limit is not 200 volts, it is near that figure. The specification suggests a standard normal voltage. If one dropped it to 150, that would be within the specification. The respondents suggest that it may be dropped to 20. (The respondents are not going to say the voltage was too high; they are going to say the current was too high.) The respondents' experiments were made at 10 volts, in series.

The first criticism made on the appellants' experiments by Mr. Swinburne was that the voltage was too high, and then the appellants made experiments with lower voltages. There is no evidence to show that the increase of the electrical resistance of the peat is due to the decomposition of the hydrocellulose. There is a great difference between a statement that one must avoid heat and a statement that the result is due, not to heat produced electrically, but to the current. There is no statement that if one does heat one will not get the result. It does not matter whether one does get heat from electricity. Electricity does not, apart from heat, help to decompose the hydrocellulose; that is the whole issue. The justice rejected the experiments, although they are comparative. It would have been a useful direction, to state the current density, that is the ratio of the product of volts and amperes to the amount of material—how many kilowatts per kilogram. The respondents' experiments made by the experts, show insufficiency. The respondents say that the applicants ought not to have used carbon electrodes, but there is no direction not to do so. There is not one of the respondents' experiments that shows that electricity, apart from heat, has a good effect. Their experiments are not comparable.

The respondents' summing up in answer to the above argument is abstracted below:

There are two questions: (1) Does the process give the

desired result, when electricity is not used for heating? (2) Does the specification give sufficient instructions? The appellants say that the specification does not tell one not to heat. They use the term electric density with two different meanings; the term current is preferable. The evidence as to utility does not rest on three or four experiments. In one experiment an advantage of 4 per cent was obtained. The apparatus designed was not made for the action; it would treat many tons of peat a day. The whole specification shows that the invention is not for heating, but for a substitute for heating, the electricity not being used for generating heat; it would be an extravagant means of generating heat, and heat does practically no good. Ekenberg left the problem as insoluble; the patentees found they could solve it, when temperatures of 100° to 120° C. were used. By using electricity, one can get a hard cake, containing 66 per cent of water, and commercially utilizable. No one had done that before. The whole question is one of economy. The appellants, in their experiments, obtained very peculiar results; they found a deposit on their carbon electrodes, and Mr. Lucas said that might give secondary results.

If the patentees had mentioned only 120° C. as the temperature of working, the patent would have been easily evaded. At 150° C. the treatment without electricity is entirely ineffective; decomposition is only beginning. The specification says that the decomposition is to be effected by electricity. The specification here is addressed not to a chemist, but to a person with a knowledge of mechanics and electricity. Such a person would know that, in accordance with Ohm's law, the voltage is unimportant as a direction, provided the current passes, also that, in accordance with Faraday's law, the amount of decomposition is proportional to the quantity of electricity that goes through the electrolyte. It is necessary to avoid using more energy in preparing the peat than can be got out of the peat. The conductivity of the peat is not known, and so the voltage required cannot be stated. Different samples of peat take very different quantities of electricity. The quantity is independent of the time, though if one performs the operation quickly one may cause carbonizing. An electrical engineer would know that the voltage would depend on the resistance of the peat, and that the resistance depends on the distance between the electrodes. There is no difficulty in varying the current to the thickness of the peat, or in varying the thickness to give the right current. There is no suggestion that the process cannot be worked with a voltage of 200. There is no objection of false suggestion. It is not necessary that the process should be useful commercially, but, in fact the apparatus dealt with several tons a day. The patentees were giv-

ing the public the best information they had in saying that 200 volts was best. The peat has to be run through at such a rate that the temperature shall be 100° C. The description of the electrode as a rod does not serve to fix the scale. It was not necessary to go into such details; the evidence shows that if the apparatus is made of the right dimensions, and the flow is adjusted, a voltage of 200 will work.

Liquid conductors of electricity are different from metallic conductors in that the latter are not decomposed in conducting. Current density properly means the current per unit of area, and the use of the term relieves one from having to state the size of the apparatus. With low currents, one decomposes the hydrocellulose and increases the resistance; with high currents, one gets charring and the resistance is decreased. Electro-osmosis does not necessarily involve decomposition, but the hydrocellulose has to be decomposed. An experimenter who has regard to the directions given will have no difficulty in working the invention. The invention differs from Ekenberg's process in the vital respect that it does not use electricity for heating. The viscosity that prevents the water being expressed is less at a high, than at a low, temperature. In the appellants' apparatus the electrodes were imperfectly insulated, there was short-circuiting, and the current was employed in heating the electrodes, and carbonizing was brought about. Pulping and heating to 120° C. never give a hard-pressed peat; electrical treatment does. The appellants say that the witnesses have said that the essence of the invention is low voltage, but Mr. Lucas said that, for practical purposes, one would not use low voltage. Two hundred volts might be described as low voltage. Ekenberg proposed to use 1000 volts, and tried 50 to 1000. Mr. Salamon has seen the process work successfully many times, and has found that microscopically the product is different from that obtained by any other method. The arguments have not disturbed the construction put on the specification in the court below. The judgment rests on sufficiency, and shows the error of the appellants' witnesses in taking a current that would materially heat. The statement of the process is a warning. If the appellants had insulated their apparatus properly, and varied the resistance properly, they would have obtained the result. The patent is of great commercial value, and attempts are being made to destroy it before the process has been commercially established.

The specification clearly shows that the expression of the water is to be effected, not by heat, but by electro-osmosis. They say that one is to heat first, and then apply electricity. The heating to a particular temperature is to be effected otherwise than by electricity, from an external boiler. It is electrical treat-

ment at a specified temperature. To establish their contention that the process is useless, the appellants have to show that to heat peat and then to apply electricity is no better than to heat only. The respondents' experiments show that when heat and electricity were used, in a test lasting 31 minutes, the pressure rose to 20 pounds, whereas, if electricity was not used, the pressure rose to 140 pounds. The greater pressure in the latter case was due to the fact that the water was not expressed so quickly as in the former case.

If the appellants' case is right, electricity is useless. No experiment was made in which there was no heating by electricity alone. As to sufficiency, the objection to the statement as to 200 volts is not pleaded; no objection to the direction was noticed at the time when the specification was read. They were given with an overdesire to tell the public all the patentee knew. The drawings are diagrammatic, not to scale. The conductivity below 85° C. is so small that it is useless to try electro-osmosis. If the passage of the peat pulp ceases, the current does not cease, but it tends to cease. The current does not produce the result by heating; that is the key to the whole attack. The appellants have consistently heated electrically. The patentees say that the current does not heat, and if the current is used for electro-osmosis it cannot heat.

The opinions expressed by the presiding judges, Justice Phillimore and Justice Joyce, follow.

Justice Phillimore's opinion:

"This is an appeal from an order of Mr. Justice Warrington dismissing a petition for the revocation of a patent for extracting water from peat by electricity. The grounds of objection to the patent are that the invention is useless and that the specification is insufficient and misleading."

Peat in its natural state contains a very large element of water. On an average, the lower and older peat may have 87½ per cent of water. Only a small portion of this can be extracted by pressure. This is caused by the presence of an ingredient often called hydrocellulose. This ingredient is not amenable to squeezing. The object, therefore, to be attained is the extraction or destruction of this so-called hydrocellulose. Dr. Ekenberg, a Swedish scientist, published a pamphlet on this subject in 1909. He discovered that if peat be macerated with water and heated under pressure to a temperature of not less than 150° C. or between 150° and 200° C., a sufficient decomposition of the so-called hydrocellulose will be produced to enable the extraction by pressure of sufficient water to make the peat a commercially valuable fuel. The discovery has been patented, and the peti-

tioners who seek the revocation of the present patent are, we are told, the holders of the Ekenberg patents.

The discovery which the present patent is designed to protect is the application of electricity to a peat treated in the same manner as that to which Ekenberg's invention was applied and heated up to a point, electricity being substituted as the decomposing agent, in lieu of the balance of temperature. Heat is required, and at least to the extent of 100° C., better a little over, and indeed it is said that any addition of heat may be helpful to the electricity. But it must be boiler heat; and electricity is not to be applied to produce heat, and if so applied is wasteful. In other words, the average Ekenberg temperature being taken as at least 160° C., and the average temperature under this patent at 110° C., 50° C., of superheated temperature is saved by the process under this pressure. It is admitted that, if this be so, the invention is economically advantageous and therefore valuable. The burden is on the petitioners to disprove the utility of the patent. But I do not think it necessary to rely on this. In my view, the learned judge was right in holding that the patentees have a useful invention. He had certain advantages which we have not. He saw the witnesses and saw the machine in working. But, without his advantages, I should come to the same conclusion. Mr. Lucas, one of the patentees' witnesses, has been working the patent for a considerable time, and speaks affirmatively of its advantageous results. So does Mr. Swinburne, who has seen it working. The experiment "J. S. 10" is a favorable one. With regard to "J. S. 10" two criticisms were made. One was that the heat at the entry of the peat was lower on the average in cases where electrical current was not applied than in cases where it was applied. But, as in either case the temperature was far lower than that at which, according to Ekenberg's teaching, heat has a useful decomposing effect, the difference between the two temperatures seems unimportant, and does not prevent the experiment being comparative. The other criticism was that the time of the A experiment with electricity was 31 minutes, while that of the B experiment was only 15. But the answer made seems a forcible one. The B experiment took only 15 minutes because they were obliged to stop it, as the filter press got choked, or at any rate a pressure rose so as to make it necessary to stop. But the pressure rose because the water was not expressed from the filter fast enough; and the fact that the run could be twice as long with electricity applied, points to the conclusion that the peat was then much more amenable to pressure and to the extraction of water.

The other experiments put forward by the patentees do not afford much assistance. Against these experiments the petition-

ers had theirs. Some may, I think, be put aside. In theirs, there was no doubt an honest attempt to copy the plaintiff's process, but they were so conducted and the results obtained were so peculiar as to make them of little value. The more important experiments are "J. S. 5," "J. S. 6" and "J. S. 7." Taking "J. S. 5," there, as a result of averaging four runs with electricity and two with heat at an inlet temperature almost identical, varying from 104° to 102½°, peat which had started by having 84.22 of water, had in the end 81.0 in the case where heat, and 81.3 where electricity was applied. The other two, "J. S. 6," and "J. S. 7," produced results generally similar.

The patentees' witness, Mr. Swinburne, said frankly that, as far as he could see, the machine which the petitioners had constructed fairly reproduced the necessary conditions, and that he saw great difficulty in explaining the unsatisfactory nature of the result. Unfortunately neither he nor the other witness for the patentees ever saw this instrument in working, or indeed, anything but a diagram of it, though the original was produced to us in court. He made certain suggestions at Questions 626, 627, and 636. They were tentative merely. During the argument before us, Mr. Bousfield said that, having had further time to consider the diagram "J. S. 4," he could indicate certain dissimilarities in the instrument they had described from that used by the patentees, which might be the cause of the peculiar nature of the result. There is a small portion of the tube in which the rod forming the electrode works, which had not been insulated. Whether this would have any effect we cannot tell, as owing to the point not having been discovered, no opinion was obtained about it from any of the witnesses. The matter must be left in this condition. However, the results of the experiments, particularly of "J. S. 5," and "J. S. 6" are startling. The peat, which is passed in at the inlet temperature of between 102½° and 104° was heated to various temperatures ranging from 106° to 115° in "J. S. 5," but the electrode, which, in the cases where there was no electricity, rose to 111° or 133°, rose in the electricity cases to figures varying from 145° to 168°, pointing to something which conveyed enormous heat to the electrode, and wasted electricity by so doing. Corresponding results were obtained in "J. S. 6."

As it is entirely contrary to the patent that the electricity should be expended in heat, it would seem that something had gone wrong in these experiments. Mr. Lucas made a suggestion at Questions 1151 to 1155 which might be a dangerous one for the patentees, and he repeated at Question 1332 and 1333, and 1353 to 1359. This was that, if too strong an electric current were applied, the process known as "arcking," making local

bridges between elements of peat which would send the current through those points and leave the rest untreated, might apply. This suggestion, as I have said, is a dangerous one for the patentees because they might have some difficulty in showing that they had guarded against in their specifications, or in supporting their specification if they had not guarded against it. But it is, I think, only a theory of Mr. Lucas; and, of the two expert witnesses for the petitioners, Mr. Ballantyne. At Questions 2445 to 2466, does not believe that arcking occurs, and says at Question 2725 that it would be detected in a moment. Mr. Clerk's evidence at Questions 2859 to 2861 is also opposed to this idea of arcking.

To sum up, it is difficult to explain the results achieved by the witnesses for the petitioners; but there are various loopholes for error. Though the experiments were all made in good faith there are indications on the face of the results that the experiments were not conducted according to the patent, and therefore would not displace the positive testimony, not only of isolated experiments, but of continued user, by the patentees, and the evidence of Mr. Salamon at Questions 1405 and 1410. I come, therefore, to the conclusion that the patentees show that their claim is sound, that is, that they can extract water from peat by "passing an electric current through a pulp of the same, heated to a temperature of 100° to 120° C., under a pressure of about 10 atmospheres.

The other point raised against the patent is more serious. It is an objection to the specification, which is said to be insufficient and misleading. It will be necessary to take the passages objected to seriatim. The first objection is on page 3, line 2, and the contention is that patentees incorrectly state that a sudden change occurs in the conductivity of peat at the temperature of 85°. I think the learned judge was right in the view that he took of this passage and I adopt his words: "They are in my opinion simply stating that the conductivity of peat improves with increasing temperature, and that at and over 85° it has so far improved that the current can be advantageously applied. In other words, that one should not attempt to work at a lower temperature than 85°, but one may work at anything over that." There is an increase of conductivity at 85° and the curve which represents the relations is to a certain extent altered at this point; but the patentees do not claim that the conductivity reaches a useful degree until the temperature is at least 100°.

The next criticism which is it is convenient to deal with is at line 45, where occurs the following statement: "If the passage of the peat pulp between the electrodes be arrested, the electrical current automatically ceases to flow, as the peat ceases

to conduct electricity immediately the hydrocellulose in it is decomposed." As an absolute statement, this is incorrect, but it is not for any material purpose incorrect. Peat, in which the hydrocellulose has been decomposed, offers increased resistance to the electric current, and this tendency increases with the decomposition. This is admitted on all hands, and this being so, the absolute, instead of the relative, form of the expression is not, I think material. Indeed, the witness for the petitioners did not point to this passage as misleading for any important purpose, taken by itself.

The most serious criticism is on the passage line 10 of page 3: "The voltage may vary within wide limits, but a voltage of about 200 has been found to be on the whole the most economical." It is said that this is insufficient, because it gives so little guide as to the amount of voltage, and that it is misleading because it encourages as large a voltage as 200, which is unnecessary and wasteful, and would be, if Mr. Lucas's view as to arcking was substantiated, even injurious. The patentees contend that they had pointed out (and this is quite true) that the electric current with their process is not intended to heat the peat, and does not do so to any appreciable extent, and that the decomposition is not due to heat generated by the electric current acting as an electrical heater. This is stated on page 4, lines 6 to 10. An experimenter, who, with this last passage before him, found that he was adding appreciably to the heat of the peat, would see that he was misapplying in some way his eleectric current. Whether he would learn from this any further warning than that which he was doing was economically wasteful may be a question but he would at least learn that he was not on the right road.

The recommendation of a voltage of about 200 has an historical origin. It was that which was used, and successfully used, in the first experimental laboratory plant. But it is far in excess of that which the patentees use with their present demonstrating plant. It is not a high voltage in one sense, nor, I think, a low one. One of Ekenberg's experiments was to use electricity without a minimum of heat, and when doing this he tried currents of 50 to 1,000 volts, and this fact was, of course present to the patentees. Scientifically, as I gather, the question is not one of voltage but one of amperage, and to get the requisite amperage you must vary your volts according to the number of ohms in the substance to be treated. First of all, this will depend upon the distance between your electrodes. The patentees, with their specification, submit two drawings which are diagrammatic and not to scale. Mr. Ballantyne assumed that, because the word "rod" was mentioned, he

was entitled to treat the central electrode as not more than an inch and a half in diameter, and then treated Figure 2 as being to scale, and got his dimensions accordingly. On these dimensions, 200 volts would be excessive. But he said, at Question 2380, that if he was not tied to Figure 2, he "could work it out so as not to get any heating effect worth speaking of, using 200 volts." And so said Mr. Lucas, at Question 704. The second factor depends on the conductivity of the peat which is passing between the two electrodes; and that varies very greatly. In fact, all that the patentees could say is that you must apply such a voltage as by experiment will be applicable to a machine with the electrodes at a particular distance apart, and to the varying qualities of peat which you pass through the machine. The passage as to 200 volts, though it would have been, in my opinion, better away, was correct as a piece of historical information; and as, I think, any electrician would know that it was not voltage but amperage that would have to be considered, is not misleading. The terminus ad quem, or limit of the voltage, is given when we are told that a current must not generate heat to any appreciable extent. It is perhaps worth observing that the point of objection as to this passage is not taken in the particulars of objections. I have less difficulty on this point because I do not think that Mr. Lucas's theory is proved, or that there is any greater danger from using excessive electricity than that of waste, that waste tending to diminish as the hydrocellulose becomes decomposed.

These are, I think, the only objections to the specifications. It is, in my opinion, not misleading, but states a valuable discovery, with a direction which is a little vague, but which in the present state of knowledge upon the subject, and until more is known of the quantity of ohms in particular classes of peat, or the quantity of amperes necessary to produce decomposition of possibly varying kinds of hydrocellulose, is as precise as it can well be. The counsel (for it is no more) to use 200 volts is sufficiently guarded by the counsel that you are not to use a current to produce heat. The course to be steered between these two is a matter of particular and practical application.

I think, therefore, that the learned judge was right in dismissing the petition for the revocation of the patent.

Justice Joyce's opinion:

This case, to my mind is one of considerable difficulty. The best consideration that I have been able to give to the evidence, so far as I understand it, has not brought me to a positive conclusion upon the question of the utility, or otherwise of the alleged invention, the subject of the patent impeached. At all

events, however, the present appellants have not succeeded in convincing me that the patent is bad for want of utility.

Upon the other question, namely, whether the specification is sufficient or misleading, the argument on behalf of the appellants appeared to me to require very careful consideration. But upon the whole, I do not feel justified in overruling the decision of the court below upon either question, and consequently I agree that the appeal be dismissed.

Obtaining Peat for Home Purposes

By Fr. Berg, Sagnitz, Livonia, Russia

The Most Primitive Way.

On page 14, volume 8, of your journal, John N. Hoff, New York, says, "to make the production peat fuel successful in our country, it should cost not to exceed $1.50 per ton to produce, to compete with coal at $3 per ton having about double the heat value of peat."

This is the reason I use for home purposes the raw peat as it is dug and air dried. The bulk is of little consequence, as long as no distant carriage is to be considered.

All the different descriptions of preparing peat your journal has hitherto given concern the compact, macerated, pressed or otherwise prepared peat. Such preparation is indispensable for distant transportation, but for local use the ton of peat is cheapest in its natural state. The small farmer may drain part of a bog by open ditches, deepening them gradually several years in succession, as the deeper layers may prove too soft, or even fluid to form the bank of a ditch at once. With a sharp, flat and narrow steel spade he may cut thin blocks of peat and place them first immediately on the dry edge of his ditch or pit; when they get firmer by drying, he must pile them higher and higher in hollow hillocks, and finely stack them, or, if possible, take them into a shed. Under cover they will further improve and get still dryer during several months or even a year. The worst period for drying is while the blocks of peat are lying on the ground; they then soak up the dew and damp from the wet soil. A layer of birchwood or rushes, spread under the peat blocks, will prove favorable.

This most primitive way of drying peat for fuel was used for centuries in Northern Europe, and it will answer a small want when no better fuel is available. Besides that it will give occasion to the user to make acquaintance with this substance, which seems so promising, but easily causes losses to those who try to use it commercially without knowing the details of its particularties.

The Way I Prepare Peat.

The next stage of perfection is the way I cut my peat now.

The peat bog must not be drained, the water in the pit must stand nearly level with the surface of the soil. I have an open drain to carry off the surplus water, but I regulate

the surface by a sluice. I use a hand-power machine for cutting and lifting the peat from a depth of 10 to 12 feet. This machine is built in Germany, (Torf. Stehc. Maschine von Bresowski Jasenitz Stettin.)

For this purpose the peat must be soft, in order to allow the 3 blades (knives) of the machine to enter it easily, a column of peat 1 foot square is then raised, this is possible only in water, As soon as one foot of this column rises above the water surface, a second man with a broad shovel, cuts off one cube after another and places them on a board which runs on wheels on a railway made of two planks with a band of iron on the top. Whilst the second colunn is cut, this man pushes the rolling plank towards the drying framework made of poles, there he cuts the large blocks of about 1 cubic foot into 4 pieces, and a boy places them on the elevated framework.

This framework is the essential thing, the peat exposed to the sun and wind on all sides dries easily and perfectly without any further hand labor, until it is perfectly dry, then it is placed into small sheds where it remains until it is used. Most of it is carted in winter when the bog is frozen but I have no difficulty in making a small road into the bog, which permits access at all seasons. An old horse and a boy are able to cart light loads, which look bulky, to my steam engines for thrashing, sawing lumber, or producing electric light, also electric power for water pumping and grain sorting machinery, etc.

This fuel turns out to be cheaper than wood and I have no difficulty in preparing the rather considerable quantity I want. I can highly recommend this system for home use in the country. My grandfather, my father and I have used such unprepared peat fuel now for more than 100 years. I have tried different machines for preparing compact peat, but the cost of this fuel is far higher and its heating power nearly equal to the same weight of raw peat, on condition that it be as dry, this is the essential point, and it can safely be reached only when the wet blocks of freshly cut peat are immediately placed on elevated stands. Those stands may not be easily procured everywhere in America; in my district wood is scarce, but the forests are somewhat cultivated, and the thinning of a cultivate young wood gives cheaply the material required—poles 1½ to 2½ inches thick.

Peat For Litter.

I also use a great amount of peat litter, which I make myself, for a herd of about 500 head of cattle besides horses, etc.

The litter made by the upper layers of the bog, which consists largely of sphagnum moss, is generally recommended as

the only good litter. I consider it also to be the best, and now use principally this kind of litter, but I have used for many years litter made of any block peat I could easiest get, and I found it so useful that I am sure that any farmer who ever tries it will not stop using it. If he daily adds for every cow 1 to 2 pounds of black peat litter reasonably dry to the straw he uses as a bedding for his cattle, he will find his herd will be kept much drier and cleaner, and he may be sure that the quantity of his manure will turn out nearly double of what he formerly had, the quality being also greatly superior.

Scientifically made experiments show that some kinds of yellow sphagnum litter may imbibe double of even four times as much liquid manure as some black peat varieties, this is all very well, but when the soft moss litter is piled up in the drying heap, the pressure of the heap causes the sewage to run out again, as the water will run out of a soft sponge when pressed. So the field that is to be manured will get only a part of what this soft litter had formerly imbibed.

For making the first trial I would suggest plowing and harrowing any litter of peat at hand. when the upper layer gets reasonably dry, pile it up into heaps and use the half dry litter as an addition to straw in your cattle yard or cow shed. after seeing its value you will probably not leave off using it, but try to improve it and begin to dry the peat more perfectly, and then to break the pieces with a wooden block, or even put them through the drum of an old spike threshing machine in order to grind the pieces as much as possible into a powder.

ANNUAL MEETING OF THE GERMAN PEAT SOCIETY.

The annual meeting of the German Peat Society took place in Berlin on Feb. 21, 1916. The chairman, von Schorlemer-Lieser, in opening the meeting, noted the importance of producing as much fodder on the peat bogs as possible and of utilizing peat straw. Dr. Alves, the secretary, then presented the business reports of 1915. On account of the availability of a large numrer of prisoners for working the peat bogs, in many places preparation for cultivation could be undertaken. The society again received financial assistance as follows: $5000 from the imperial treasury, $18,600 from the government potash fund, and $2,400 from the Thomas phosphate Manufacturers Association.

In the technical division considerable time was spent in experiments on fuel combustion. Many discussions were held covering the working conditions of different deposits and the utilization of the peat for industrial purposes, firing under

boilers and heating, gasification and coking, dewatering peat, use of peat fibre in plates for insulation, and use of peat dust for firing.

Hemp and Peat Cultivation.

Dr. Augustin read a paper on the growing of hemp on peat meadows. About nine years ago the author sought a plant that would overcome the soil fatigue occasioned by beets and found after several trials that hemp was the desired plant. Sight was not lost of the fact that the cultivation of beets was to be maintained. It was demonstrated that hemp would grow on peat land, that the fiber was strong and the hemp from the peat land was not inferior to the imported product. Hemp prospers on all humus soils but not in sandy and clayey soil; under no conditions will it grow in acid soil. The rapidity of its growth is an advantage as a weed preventative. Hemp stands a drought well and the reported bad effect of frost is not correct. Hemp is especially responsive to potash fertilization. Whether nitrogen fertilization is necessary depends on the nitrogen content of the peat soil and its availability. High moors require liming, and the treatment of low moors it depends on the amount of lime present. For peat soils only the fiber and not the seeding hemp comes into consideration. As only 18 to 20 per cent of the plant consists of fiber and the 80 to 82 per cent as ballast it will be necessary to establish central stations for working the plant to make it worth while for the farmers, so that a good fiber is obtained which will be acceptable to the industrial uses. The German Hemp Growers' Association will erect steeping stations. In normal times the price is 92 cents per 100 pounds during this year there will be a war tax of 50 per cent. There is no need of fearing that available space for food materials will be taken up by the hemp. We have still eight and a half million acres of uncultivated peat deposits and only 130,000 acres will be necessary to cultivate the necessary amount of jute to correspond to the amount previously imported.

Hemp Cultivation and Its Meaning for Peat Cultivation. (Dr. Stoermer.)—The return to hemp cultivation in Germany is considered in several respects by the author as a going backwards. Large quantities of hemp used to be grown in Germany; for instance in 1870 there was still 52,000 acres under hemp, whilst in 1905 there was only 8,000 to 9,000 acres. The cultivation of hemp will under the new conditions create a new agricultural industry, and the installation of steeping stations will undoubtedly be an advantage to the industry. The German Hemp Growers Association will at present erect four steeping stations in northern Germany. The capital will be provided chiefly by the textile industry. The discussion brought out sev-

eral satisfactory statements on the advantages of growing hemp on peat. Bavaria has a large jute industry and therefore is a good center for cultivating hemp. It was brought out at the meeting that everything will be done to encourage the cultivation of hemp, and steeping stations will be conveniently located wherever a need for them exists and will not be confined only to northern Germany as was the impression.

Mistakes in Cultivating Peat Lands (Dr. Tacke). The author referred to mistakes that are always recurring. As regards soil constituents chemical analyses correctly indicated these. The biggest mistakes are made in the drainage; local conditions and proper draining plans are paid too little attention. Also in fertilizing peat soils errors are made, as a rule; too much phosphate and not enough potash is used.

Experiences on Low Moors (Freckmann). The treatment of low moors, when the surface is very dry requires careful judgment. The author describes methods of preventing the dusting of the surface and what means to take on surfaces already dusted. The author gives his experience with raw phosphate and the effect of copper sulphate on different fruits. As a result of experiments since 1901 he uses powdered copper sulphate several weeks before cultivation in quantities of about 1 ounce to 11 square yards. By this means greater yields have been obtained, which was not possible by other methods. It is assumed that the copper sulphate increases the chlorophyll formation.

Irrigation of Peat Lands

By Mrs. Fred Osborne, Ann Arbor, Mich.*

If our 30-inch of rainfall were evenly distributed over the growing season, there would be no need for irrigation in the eastern United States. But there are seasons of drought when the soil moisture is evaporated.

Plant foods such as phosphoric acid, potash, lime, magnesia, iron, and sulphur must be taken from an inert solid form in the soil into solution in water before they can be of any service in plant growth and this is another important role that water has to play in the life processes of the soil. It is, however, impossible to overestimate the importance of water as a plant food or as a conductor of plant food.

Plants are stationary. They can't rise from their beds each morning and seek food where the pasture is most nourishing; they must wait or languish until food is brought to them, and their very existence depends on the supply equaling the demand.

Water contributes more than half of the materials that make up the dry matter of plants, and water constitutes three-fourths to more than nine-tenths of their green weight. In lettuce it is 95 per cent.

Now our first question becomes, How shall we supply the plant at all times with the proper amount of their essential?

By scientific methods, of course. And that means that the farmer is to cease to depend on the dry or the wet of the moon. The signs of the zodiac are no longer the criterion of his success. Come, let us reason together. Let us ask by what principles results may be brought and then let us appiy them to our industry of farming until we tillers of the soil are working on as sane and logical a basis as the kings of finance.

Water being essential to plant growth, we look to the provision of it. Outside the natural rainfall, there are three methods, as follows:

Overhead irrigation, subirrigation, and the furrow system.

Overhead Irrigation—

Overhead irrigation consists of a series of small pipes fitted with nozzles that break the drops of water into a mist, thus providing an even distribution of waterfall. It is considered by some the best method but its objection is its cost, this being $150 to install this system on an acre.

*Read at the Detroit Meeting, 1915.

One also has to consider the nature of the plant for which it is used as it sometimes carries the water into the heart and in hot weather starts heart rot.

Subirrigation—

To subirrigate a piece of land, one should have a main line of tile running down the field from the highest to the lowest side, and should have laterals extending out on each side with stop boxes or overflow pockets set in the line of the main at frequent intervals, the laterals being 25 to 35 feet apart so that the water may percolate through the soil. The head or ditch should be on the highest side of the land. This method is considered by the Department of Agriculture, as expensive and not liable to succeed except under unusual soil conditions.

The Furrow System—

In the use of the furrow system, as with subirrigation, the supply of water must be at the high side of the land. Your field must be leveled to a fall of about eight-tenths of a foot to 40 rods.

The furrow is dug the length of your field with a common wing shovel, a tool familiar to every farmer.

The field and the furrows being in readiness, common conductor pipes are used to carry the water into the furrows, thence down the length of the field from such water supply as may be available. Artesian wells are best as it costs money to pump water.

In this system the water while flowing down the length of the furrow, sweeps out into the soil, saturating it on both sides, the amount of water used being learned by calculation.

On the nature of the soil depends the distance between the furrows, as it is obvious that water radiates more easily through loose soil than through heavy.

The word "irrigation" as Webster defines it, is the carrying of water over the surface of the soil. From our repeated experiments and observations, we seem to evolve nothing better and consider the furrow system the cheapest and simplest for the ordinary person to obtain the best results.

As irrigation becomes a process of general use it evolves other problems. One is the ownership of the streams and natural sources through which this irrigation is supplied. A controversy as to the matter of ownership must of necessity arise, unless the State shall have supervision and the waters of the State shall be meted out by a wise administrative officer or an equally wise engineer whose authority shall be unquestioned in the dispensation of the water rights, both to the individual and to the public at large.

Peat Humus

By Robert Ranson, Pablo Beach, Florida*

It is some time since I have had the pleasure of attending a meeting of the Society. Some months after we met in Ottawa, Canada, in 1910, I visited England and saw the Mond works there, and afterwards went to the continent. In Germany I visited a plant which had a capacity of 150 tons of peat daily, by which 4500 horsepower was produced and distributed. In the following year the Mond people sent a representative to Florida, and later on they bought my property there with a view to developing a plant similar to the one at Osnabrück, Germany. The peat on the property was found to be very suitable for the employment of the Mond process, being very rich in nitrogen.

Plans were well advanced for the erection of the plant, when the outbreak of the war stopped proceedings, and we have been at a standstill since. I have, however, gone right along with the manufacture of a special humus fertilizer from peat, for which I have built up a considerable trade, and which has been used with excellent results. The peat that I use for this purpose is excavated and spread out, being exposed to the action of the sun and air for several months. I have found a remarkable advantage to accrue from the addition to the peat of a small quantity of high grade dried blood, not more than 15 to 20 pounds to the ton being required. After the humus has been mixed, it is piled in heaps where fermentation take place. The thermometer at first would stand at 50° to 55°, then rise to 78°, where it would continue for some time.

I am selling the humus prepared by this process to farmers, and they claim to obtain better results from its use than from the application of chemical fertilizers. My explanation of the amelioration is that the blood introduces bacteria favorable to plant growth, and that these are increased by the treatment. In England Prof. Bottomley of King's College, London, has been carrying on a most interesting and instructive series of experiments on introducing into peat nitrifying bacteria which will grow in the soil and not depend on the roots of plants, such as the nodules of clover and other legumes. His experiments with radishes and other plants other than legumes have been productive of some very striking results.

I believe the furnishing of the soil with bacteria favorable to plant growth is of the greatest importance. And may not

*Read at the Detroit Meeting.

some of the unfavorable results attributed to acidity of the soil be due to lack of these favoring organisms?

Discussion.

Prof. Patten: Sourness and acidity are sometimes confused. What is called sour soil due to bad drainage is often due to a growth of molds.

Mr. Ranson: Drainage is no doubt essential. Peat reduced to 10 per cent moisture is as dry as gunpowder. We sell our fertilizer at 20 to 25 per cent moisture. It seems to me the time has come to get back to nature's fertilizers. The practice has been to depend too much on chemicals—nothing but inorganic matter. If we can get our nitrogen from an organic source, such as peat, our phosphoric acid from bones, and potash from wood ashes, we will have better fertilizer. In many cases in Florida our orange groves are chemically sick. The use of humus brings back fertility to the soil. I have no sphagnum moss on my bog, but it is covered with a heavy turf which run through a bog makes a perfect peat litter.

Mr. Ranson closed by reading an invitation from the St. Augustine Chamber of Commerce to the Society to hold its 1915 meetings in that city.

Prof. Allen: Prof. Bottomley's description of his experiments looked good to me. I started some experiments at our Agricultural College, and have a number of plots laid out on which they are being conducted. My pot experiments were a failure, owing probably to some oversight. I believe the future of peat in this country rests largely on the use of peat as a fertilizer, and on the special value it has as a medium for introducing into the soil bacteria favorable to plant growth. I think Prof. Bottomley's experiments are proceeding on right lines, and should give some very valuable results.

B. von Herff: In Mexico, alfalfa is largely grown, from nine to twelve crops to 3 feet high being produced. It is found essential to use each time a little stable manure. Peat should be very useful to provide favorable conditions for the growth of plant nodules.

Prof. Patten: Farmers are apt to get the idea that chemical fertilizers alone will supply all that the soil needs for fertility, and to overlook the necessity for keeping the soil well supplied with organic matter. The unproductiveness of worn-out lands is often, if not always, due to the destruction of the humus nature has stored up in them. It would be as great a mistake to swing to the idea that organic matter alone is required. The best results can be obtained only by proper combination of chemicals and organic matter. It is really to a large

extent a question of economies whether the farmer can afford to use peat to restore humus to the soil.

Mr. Ranson: The use of stable manure has made a wonderful success of tomato culture on Florida lands on which nothing would grow before, and it pays well although the measure is expensive.

2852 Ontario Road, Washington, D. C., June 12th, 1916.

Members Executive Committee American Peat Society,
Gentlemen:

Permit me to express to your Society, through your committee, my great appreciation of the framed resolutions, on the death of my beloved husband, which reached me on June 10th.

May I also wish you the success you deserve in the propaganda work of the cause which was so near his heart for so many years, and the ultimate realization of your ideals of the Peat Industry as a great addition to our natural resources for varied uses.

Very gratefully yours,

(Mrs. Charles A.) Frances Humphreys Davis.

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EDITORIAL NOTES

Our Late Editor. Elsewhere we publish a biographical sketch of this worthy benefactor, who has done so much to enhance peat and the peat industry in this country. Mail reaching this office contains words of many appreciation and sympathy in memory of our late chief. Our publication manager, Mr. E. J. Tippett, well expresses the general trend: "......I never met him personally, yet I felt as though I knew him. His letters breathed forth such a spirit of honest sincerity and manliness that I have learned to love the man and to appreciate his worth in these last half dozen years." Our Canadian brother peaters were also shocked at learning of the death of Prof. Davis, Mr. Arthur J. Forward writes, "......It is several years since I first had the privilege of meeting Prof. Davis in Ottawa, and every meeting since, as well as my correspondence with him, not only increased my respect for his attainments and wide knowledge of peat and peat industries, but strengthened my personal regard for him as a man of most estimable character and qualities."

Contributions. We have occasionally requested our members and friends to communicate with us telling us what is transpiring in their vicinity of interest to the peat industry and agriculture, but they have evidently overlooked this paragraph as little, very little indeed has come to us through these channels. Perhaps we howled so loud those near us could not hear and only those in the distance caught our words, for we have received some excellent contributions from far away. We print

in this issue two from Russian sources of interest to all of us.

Regarding the article by Lisitzin on the Russian peat industry, a few remarks are perhaps in order. The cubic contents in Russia are measured by their unit known as a cubic Sashen which is equivalent to about $12\frac{2}{3}$ cubic yards. The figures given will be interesting for comparison with the industry here. A ton of air-dried fuel in the Moscow districts costs the manufacturer $2.20 to $2.25 per ton.

What Is Peat Good For? This question is often asked and there are a surprising number of uses to which the material may be put. In the United States peat was produced on an economic scale in 1914 for fertilizer, as a base and filler for artificial or chemical fertilizers, for use in stock foods, mud baths, as fuel, paper stock, as a source of coke or charcoal, and for insulating material, about in the order named. Some was used as a deodorizer and preservative in slaughter houses and garbage plants to improve the conditions under which tankage is produced from the refuse of such establishments, and to make a better and more salable product from such waste.

Peat stable litter to the amount of nearly 10,000 tons was imported from Europe.

In Europe, peat is produced in largest quantities for fuel, of which the commercial varieties are air-dried, cut peat, air-dried machine peat, briquetted peat, peat powder and peat charcoal or coke.

Large quantities of moss peat are prepared and sold in Europe for stable litter. Peat mull, or dust, is extensively produced as an absorbent and disinfectant in cesspools, outhouses, manure pits, etc. It is also largely used to mix with refuse molasses to make a valuable stock food. Peat mull is largely used for packing and preserving fruits, vegetables, and fragile materials during shipment, and as surgical dressing, and absorbent.

Fibrous peat is used either directly, or as a source of fiber for making hospital mattresses and cushions, and for absorbent and disinfecting dressings for wounds, etc. The selected and cleansed fibers are woven into coarse fabrics and to some extent to mix with more costly fibers, and for paper stock. The coarse, poorly-decomposed moss peats are cut or pressed into sheets 2 or more inches thick and used in the walls of buildings as insulation against changes of temperature, sound, etc., and as a substitute for cork in a variety of uses.

Mixed with other mineral substances, such as plaster of Paris, peat is made into wood and stone substitutes that have been used to some extent in cabinet and structural work.

When subjected to destructive distillation is closed retorts, peat yields burnable gas, a good quality of charcoal free from sulphur and phosphorus, and therefore useful for metallurgical processes. If the gases of distillation are cooled and condensed, chemical compounds of economic value may be recovered from the crude distillates. Among the more important of these compounds are ammonia, recoverable as the sulphate of ammonia methyl or wood alcohol, formaldehyde, acetic acid, acetone, or calcium acetate, petroleum oils of several grades, creosote, from which phenols may be separated, paraffin, and a substance resembling asphalt.

It has been proposed to obtain nitrates and nitric acid from peat by the action of electricity and nitrifying bacteria on prepared beds.

Peat has also been used as a source of dyes and of tanning materials.

Recently, properly treated peat has been reported to be an excellent culture medium for some of the bacteria most beneficial in agriculture and a large use for this class of fertilizers is possible.

Wet Carbonizing. Elsewhere will be found a lengthy report on a lawsuit regarding wet carbonization. We thought it worth while going to this length to give those interested in the dewatering of peat valuable data that may be of great assistance to them.

It might be well here to review the Ekenberg system of so-called wet carbonization. Ekenberg submits the moist peat after preliminary maceration to temperatures slightly above 300° F., and during the heating a pressure of about 150 pounds to the square inch is maintained by a force pump driving the wet peat into the apparatus. The process therefore actually depends on superheating wet peat in a closed receptacle under a pressure of about 10 atmospheres. By this means there is no formation of steam, tending to dissipate heat, and there is no volatilization of the hydrocarbon compounds of the peat. The raw peat is pulped with an abundance of water in a special machine situated on the bog, and is conveyed thence to the works and stored in a tank for use.

The furnace, which is the essential feature of the plant, consists of a series of iron pipes about 36 feet in length, heated from

a firebox at one end. Each tube is double, the smaller inner tube being fitted with a projecting screw flange which, when the tube is turned, moves the peat through the annular space between the two tubes, fixed concentrically. The inner tube is left open at both ends, and at its free end is connected with the corresponding ends of all the rest of the series. Each of the large outer tubes is connected with a common inlet through which the peat is pumped into the apparatus. At the end opposite the inlet the large tubes project into the firebox, and they are thus exposed for half their length to the direct heat of the fire. The peat pumped into the common inlet is forced through the tubes by the pressure of the pump and the screw flanges of the inner revolving tubes, which act as a conveyor. The peat under treatment is thus directed wet and hot into the open end of the inner tubes, and through these to the outlet. By this means the cool material is rendered hot before it reaches the directly heated part of the system, and the outgoing material yields up a considerable part of its heat before it reaches the outlet. From the carbonizer the peat is conveyed to a special type of filter press, by which the percentage of water present is reduced to about 10 per cent, and the pressed compound is finally desiccated by artificial heat and made into briquets

After treatment the peat becomes more or less blackened and fine grained, and nearly all traces of the original structure disappear. This change is said to be due to coking at low temperature, but, whatever the effect may be, the peat after this treatment parts more readily with the water and a definite change takes place in its composition. The briquets are hard, heavy, and black, and are stated to approximate coal in fuel value.

Annual Meeting: The majority of those from whom we have heard favor a place between the Northern and Southern part of the States and have suggested Washington, D. C., as a place where such a meeting should be held. The Executive Committee have therefore decided to hold the next annual meeting at Washington, D. C., on Sept. 21, 22 and 23, 1916. There will be much of interest to our members to be seen there, especially at the experimental farms at Arlington, where agricultural peat tests are being conducted. Every member is earnestly requested to be present and to bring as many interested friends as he can muster. Provisions will also be made for the entertainment of our lady guests.

Peat Industry for 1916. Reports reaching us from various parts of the country indicate that the peat-filler and the peat-humus industries will enjoy a banner year. Manufacturers, we understand, are running their plants to full capacity.

Fox Lake, Michigan, Peat Muck. The peat muck found in Fox Lake near Muskegon, Mich., contained about 43 per cent ash and 2.25 per cent nitrogen. According to reports promoters of this pleasure resort had intended to remove this material as it is a nuisance to bathers and boatmen. Their intention of using this muck as a fuel or as a fertilizer is possibly not feasible on account of the high ash content.

Danish Peat Society. The Danish Peat Society are this year celebrating their fiftieth anniversary and as a fitting memento for such an occasion have published a volume containing accounts of their achievements as well as of those who are responsible for the building up of the industry, agriculture and forestry on peat lands. The volume, a copy of which we have received, also contains some original contributions.

Utilizing Danish Turf. In order to meet the threatened fuel famine resulting from the British coal restrictions, the Danish Government issued an order to all municipalities to take care that every bit of turf and moss is utilized to the fullest extent. If private owners do not make use of this fuel, the municipal authorities are to take it over and prepare it for consumption. The entire scheme is under the general control of the well-known Danish Association for Heat Production.

(The Colliery Guardian, Vol. III, 1916, p. 822.)

Alfred, Ont., Peat Plant. This well-known peat plant has stopped manufacturing on account of the lack of capital, the owners being unable to secure further funds on account of the European war.

A brief history of the plant follows: In 1910 the Canadian Government bought 300 acres of bog at Alfred, and set up and operated for two years an Anrep plant with hand excavation and distribution by a field press and movable tracks. Their experience demonstrated the necessity for eliminating hand labor as far as possible. Meanwhile Anrep invented a mechanical excavator. Mr. Shuttleworth, the president of the Canadian Peat Society, became interested in the matter and on discontinuance of operations by the Government bought the bog and erected a mchanical excavator according to Anrep's patent. As the movable track system had not sufficient capacity to handle the output of the excavator, E. V. Moore devised a cableway system which has been completed and was operated last season.

Two seasons were taken up in developing the new plant. Mr. Shuttleworth then went to England shortly before the outbreak of the war, and has remained there since. Mr. Moore and Mr. H. P. Bell of Toronto bought out Mr. Shuttleworth and undertook to form a company to operate. Owing to the financial stringency they found it impossible to raise money, and eventually the company borrowed some money to carry on work in 1914. The outbreak of war led to closing down of the plant, and the company went into liquidation. Last year the plant stood idle until August when a local firm at Alfred leased it and made about 900 tons of fuel in a little over a month, working until the end of the season for gathering peat. Part of their output was sold at $3.50 a ton f. o. b. the bog on the Canadian Pacific Railroad siding, and the balance of it was stored for the winter.

The plant has been completed and is in working order, but has never yet been operated for a full season. As it stands it is probably one of the best peat plants using a mechanical excavator. It has been described in our Journal and also in the Canadian Peat Journal and is the last word in mechanical peat plants. Between $40,000 and $50,000 has been expended on the property and equipment, and in development of the plant. The whole thing can now, we understand, be bought from the liquidator for a song, and we feel that it would be a blow to the peat industry on this continent if this plant should be left without operating.

The fertilizer manufacturers in Canada state that there would be a market for the entire output of that plant as a fertilizer apart altogether from its sale as fuel; as coal is worth $7.50 in Ottawa and the plant is on the Canadian Pacific Railroad, with its own siding 40 miles from Ottawa and 60 miles from Montreal, a good trade in fuel should be able to be worked up. Peat fuel retailed in Ottawa last fall at $5.75 per ton delivered.

Abstracts, Patents, Etc.

Herbert Philipp, Perth Amboy, N. J.

Making Sphagnum Peat Useful as Fodder (A. Stutzer, Vers. Stat., vol. 87, 1915, p. 215).

The author assumes that it is possible by some chemical means to make the organic matter in peat more digestible, so that greater quantities can be used as fodder. He claims to have found such a process, involving the steaming of the peat with diluted acids (1 gram hydrochloric acid per liter) under a pressure of 45 pounds. By this process are destroyed the tanning constitutents of peat which also make the proteids insoluble. The peat is then digestible. Of the raw peat 20 per cent is digestible; of the treated peat 60 per cent is digestible. These results are considered valuable so that in times of need this fodder material could be used.

Sphagnum Moss for Surgical Dressings. The use of bog moss as a hospital dressing has been one of the interesting medical developments of the war. Indeed, as far as this country is concerned, it might be said to be one of the discoveries, for though the value of the moss as an absorbent for wounds has been known for nearly 30 years, very little had been done to test its properties.

Ireland with its vast area of 1,575,733 acres of peat bog contains an inexhaustible supply of this sphagnum moss, and under the superintendence of Mrs. M. C. Wright, the Royal College of Science have established a depot in the college for the preparation and despatch of the moss to the military hospitals. There is a subdepot of the Irish War Hospital Supply, and to them is assigned the entire work of receiving, treating and forwarding the finished moss dressing. On three days every week, some 40 or 50 willing volunteer workers are busy dealing with the bulk consignments from the country, sorting out the samples, and making them into neat packages in three different sizes, to suit the various kinds of dressings. When they commenced their work in November, they undertook to supply 5,000 dressings a month. This they have well maintained, and this month's output has been well over 7,000 dressings. The preparation of the article is of the simplest. It needs only to be properly dried to be ready for despatch. Sphagnum, moreover, is the most widely distrib-

uted of all the peat mosses. While it is most common in lowland bogs, it is also found in mountains, and wherever there are deposits of peat.

In the Edinburgh Infirmary lately an experiment was made with 5 pounds of fresh moss which was pressed and slowly dried by heat. It was found that the dried plant which had held 4 pounds 6 ounces of water, itself weighed only 10 ounces. Careful scientific inquiry has demonstrated two points of superiority for sphagnum over cotton wool—one is that the moss will absorb until every cell in the pad is full before it exudes, and the second is that it is a deodorant.

It was after communication with Dr. C. W. Cathcart, of Edinburgh, who has pioneered the use of sphagnum dressing in these islands, that Mrs. Wright and her coworkers started the preparation of the moss at the Royal College of Science. Supplies are received from almost every county in Ireland, and after being carefully picked over by the depot workers the best quality is made by them into standardized dressings, including pads of three different sizes. Bandages for the leg and for the arm, and the chest and back bandages resembling pneumonia jackets. The poorer qualities of moss are used to make splintpads, and elbow and knee cushion supports. Work has been sent to the British Red Cross Society for distribution in the hospitals at home and abroad, to the Croix Rouge francaise for the French Hospital, and by special request to two hospitals in France and one in Belgium. (Irish Industrial Journal.)

The Manufacture of Bacterized Peat. In connection with the project of the Manchester Corporation to manufacture bacterized peat under a free license granted by Professor Bottomley, the cleansing committee now estimate that the cost of manufacture for the first year will be about $1,500 to $2,500 for labor, and $1,000 for carriage of the raw peat from the Chat Moss Estate to the Holt Town Works, where the process of manufacture is to be carried on. The France committee anticipate that if the experiment is successful, the receipts from the sale of the bacterized peat will more than cover the estimated expenditure.

Bacterized Peat. (Midland Agri. and Dairy Coll. Rept. on Field Trials, 1915.) Bacterized peat is sent out in two forms, viz: (1) As a fibrous material for incorporating with the soil, and (2) as a powder for top dressing.

The powder was applied as a top dressing to wheat and "seeds" hay at the rate of 7 cwt. per acre, but produced no result whatever on either crop.

The fibre was tested with potatoes, 5 cwt. per acre being used. The results were again entirely negative.

Sterilization of Peat Soils With Carbolineum (A. v. Nostitz, Landw. Jahrbücher, 1915, vol. 48, p. 587). Hiltner, Loew, etc., obtained an increased yield of vegetation by soil sterilization. Their experiments covered chiefly mineral soils, the author therefore set to work to determine the effect on peat soils to study if the same results were obtainable. He found that by treating the soil with carbolineum (a mixture of heavy coal tar oils) an increased crop yield was produced; a lesser increase was obtained with chloride of lime, and no increase at all resulted from the use of potassium permanaganate. Carbolineum gave the best yield when applied at about one and one-half ounces per square yard. The more volatile the carbolineum the better it worked for sterilization; also better results were obtained the longer the time interval between sterilization and planting.

Fertilizing Grasses on Peaty Soils. Soils rich in organic matter respond well to dressings of basic slag or finely ground raw mineral phosphate, the latter particularly where the rainfall is abundant. An adequate supply of water, in conjunction with the carbonic acid always present in such soils, helps to render the phosphate available for plant growth. Under such conditions ground mineral phosphate is well worth attention at the present time. Pastures on peaty soils frequently require liming, and they may also benefit from the use of potash manures. If the phosphatic manure fails to prove effective in improving peaty pastures, lack of potash or lime may be suspected, and the farmer should consult the chemist attached to the advisory staff of the provincial college or the local agricultural institute. (Bd. of Agri., England.)

Reclamation of Bog Land in Ireland. In their journal for July, 1915, the Department of Agriculture and Technical Instruction for Ireland published an account of some experiments in progress in Ireland on the reclamation of bog land.

As the manurial treatment of Irish bogs appears to differ from that of Continental bogs, a series of pot experiments was undertaken with samples of peat obtained from different localities, some from the surface, others from the cut-away portion of the bog. With a few exceptions lime was found to be the controlling factor; in fact it was in most cases found impossible to grow cruciferous crops such as rape without lime, while cereals generally died out after a brief existence. In the majority of cases the effect of the absence of phosphate was more marked than that of nitrogen, while potash was invariably the least important of the four manurial ingredients.

In 1914 a small-scale experiment was laid down in the Bog of Allen. The bog (known locally as "red bog") was dug over during the previous winter and left to weather, with the intention of growing a crop of potatoes in 1915. The analysis was as follows (per cent): Water 16.87, organic matter 79.21, calcium oxide 0.19, nitrogen 0.31, potash 0.26, and a trace of phosphate acid. Rape, rye, and potatoes were sown on June 20.

The young rootlets of the rape, on the untreated plot, and those on the plot that received no lime, appeared as if burnt up as soon as the seeds germinated, with the result that not a single plant lived. Very little growth was made where nitrogen or phosphate was omitted from the dressing, and, while the want of potash was not nearly so marked, its omission from the complete dressing with lime considerably decreased the yield.

The rye germinated on the untreated plot, but was a complete failure afterwards. No grain was produced where no lime was given, and the result was little better where no phosphate was given. A fair growth was made without nitrogen or without potash, but the grain here was merely "tailings." A fairly good crop both as regards grain and straw was obtained from the complete dressing (including lime.)

The potato trial indicated that this crop is not so dependent on lime as is rape or rye, and that a deficiency of phosphate is as great a drawback as a deficiency of lime. The following figures show the approximate yield per acre:

	Tons.	Cwt.
Untreated	1	0
Nitrogen, phosphate, and potash	1	17
Nitrogen, potash, and lime	1	14
Phosphate, potash, and lime	2	15¾
Nitrogen, phosphate, and lime	3	0
Nitrogen, phosphate, potash, and lime	5	0

When the short time the peat had to weather after it was dug over, and the lateness of the season when the crops were sown, are taken into account the results may be considered fairly satisfactory for a first crop.

It would appear that fair crops can be grown on some classes of unreclaimed bog land with artificial manure and lime without the use of farmyard manure, provided the mechanical conditions as regards moisture are favorable.—Journal of the Board of Agriculture, 1915, p. 897.

PEAT-PHOSPHATE FERTILIZER.

That a big field for large investments of capital exists in the expansion of the mineral industry in Idaho and Minnesota and the establishment of fertilizer manufacturing and distributing centers in the adjacent grain states to the east, west and

south is the opinion of Robert N. Bell, State Inspector of mines for Idaho, who is now visiting New York. Southeastern Idaho, says Mr. Bell, contains vast resources of high grade rock phosphate, a partial survey of the Idaho part of the western phosphate field by the Government geologists having already outlined the existence of several billion tons of this valuable mineral.

Professor Soper, a member of the present faculty of the University of Idaho and formerly connected with the geological survey of Minnesota, who has specialized on the peat resources of the state says that the glacial basins of northern Minnesota contain tens of millions of tons of easily available high grade peat deposits, and it is believed by these authorities that a combination of finely ground raw phosphate rock and ground sun-dried Minnesota peat would form a perfect fertilizer for run-down or exhausted soil, by renewing its organic matter and primary fertility at a relatively low cost. From numerous analytical tests, Minnesota peats are shown to contain 1½ to 2½ per cent free nitrogen and to form an ideal culture medium in soil combination for the further development of nitrogen-fixing bacteria, besides furnishing abundant humus to fallow the soil, free the phosphates, and stimulate the release of the abundant natural soil potash—and be free from the objectionable feature of adding undesirable acid to already acid soils, which super-phosphate mixtures involve.

Mr. Bell believes there is a big field for mining, manufacturing, agricultural, and transportation expansion in this simple and cheap combination of rich fertilizing elements in the Upper Mississippi Valley states, in which his state can supply the most vital element, and in connection with Professor Soper intends shortly to submit a joint paper on the subject for discussion.—Eng. and Min. Jour., Mar. 18, 1916.

VEGETABLE FERTILIZER

The Fertilizer Problem from the Vegetable Grower's Standpoint, C. E. Durst, Ill. Agri. Expt. Sta. Cir. 182, 1915.

The fertility problem in vegetable growing is one of the most important of the many difficulties confronting the gardener. The general principles underlying the fertilizing of farm and vegetable crops are the same, though on account of the wide differences in the two branches of agriculture, there are marked differences with respect to the specific manner and degree of their application.

Vegetable crops remove large amounts of fertility from the soil, and comparatively large losses occur also through drainage and leaching and by oxidation of the nitrogen and organic

matter. These latter losses may be checked to a certain extent by careful methods, but even with the best attention there will be large losses. Hence, the maintenance of the highly fertile condition necessary for successful vegetable production is not a simple matter.

The organic matter content of the soil can be maintained by plowing under manure, crop refuse, and cover crops. Nitrogen can be furnished by manure, by leguminous crops, and by the various commercial forms of this element. Manure is without a doubt the best general source of fertility for the vegetable grower, though it is somewhat low in content of the mineral elements. Large losses in manure occur through improper handling, and its proper treatment under the circumstances met with in practical vegetable gardening is a rather difficult problem, and one in which many serious mistakes are made.

It is practicable for gardeners to utilize cover crops as a source of organic matter. If legumes, such as cowpeas, soybeans, and hairy vetch, are grown, they will serve as sources of nitrogen also.

Commercial forms of nitrogen, even the expensive, can often be used with profit by the vegetable grower. Nitrate of soda appears to be the most satisfactory form when used in the right way. On account of its soluble condition and the fact that plants can use it directly, it is particularly helpful in forcing the growth of early spring crops. However, it must be applied in proper amounts, at proper times, and by proper methods, or serious harm to the plants will almost certainly result.

As the amount of phosphorus contained in most soils is small, and as manure is low in that element, applications of some commercial form usually prove profitable. For immediate results acid phosphate and steamed bone meal are the best forms to use, but if the gardener will provide for his needs two or three years in advance, he can employ the very much cheaper raw rock phospate. The phosphorus in this form is insoluble, but the large amounts of manure, crop refuse, and cover crops ordinarily plowed under in vegetable growing will be instrumental in changing it to soluble forms. There are even some experiments on record which indicate that certain vegetable crops give marked increases in yields the season immediately following its application.

Potassium is abundant in nearly all Illinois soils, but applications of it sometimes prove profitable. Sulphate of potash appears to be the most satisfactory form for general use, though muriate of potash seems to give equally good results with some

crops. Unleached wood ashes are a most satisfactory form of potassium, but unfortunately the supply is limited.

Lime benefits practically all vegetable crops and should be used in liberal amounts by gardeners. Ground limestone is the cheapest form and one of the most satisfactory as well.

Finally, the land should be well drained, either naturally or artifically, and an adequate system of crop rotation should be practiced.

The factors mentioned each bear an important relation to the welfare of the plant. It is only after all of them have received proper attention that maximum crops of high quality vegetables can be produced.

DRAINAGE.

Excavating Machinery used in Land Drainage, D. L. Yarnell, U. S. Dept of Agri. Bul. 300, 1915.

Power machinery is now available that will construct outlet drainage ditches of all sizes, and under all conditions of soil and water, cheaper than can be accomplished by any other method.

The floating dipper dredge is more widely used in drainage work than is any other type of excavating machine. For work through wet land no other excavator will equal it in cheapness of construction of ditches having a cross section of 100 to 1,200 square feet. It is by far the most efficient machine to use where many stumps will be encountered. Owing to its limited reach it is not generally applicable to levee construction. Dipper dredges as constructed for drainage work rangein capacity from one-half cubic yard to 4 or 5 cubic yards; the sizes most commonly used vary from 1 to 2 cubic yards. The smallest dredge costs about $5,000; the cost increasing rapidly with the capacity of the dipper. The floating dipper dredge should be operated downstream, where practicable.

In general, the clamshell, or orange peel dredge is not well adapted to ditch construction, especially if there are any stumps to handle. Certain types of soil, such as the muck of southern Louisiana, can, however, be handled to advantage with this machine. It is also suited to levee building when equipped with a long boom.

The drag-line scraper excavator is constantly increasing in favor in drainage work. It is especially suited to the construction of ditches and levees of large cross section, where the ground is sufficiently stable to support the machine. The scraper excavator is also suitable for ditch cleaning.

The various forms of so-called dry land machines find rather extensive use in drainage. The dipper and orange peel dredges

of the dry-land type are suitable for use where sufficient water can not be had to float a dredge. The templet and wheel types of excavators are applicable to open land where the soil is neither too hard nor too wet. The ditches cut by these latter machines are superior in hydraulic efficiency to those of similar section cut by any other type of excavator. The dry-land machines should be operated upstream.

The hydraulic dredge is not suited to ordinary drainage ditch construction. It has been used to some extent in cleaning ditches, and, with the use of slope boards, has in at least one instance made a satisfactory record in levee construction.

THE SIGNIFICANCE OF PEAT IN INDUSTRY.

(E. V. Verschoor, Chem. Weekblad, Vol. II, 1914, p. 980).

There is little prospect of any increase in the use of peat as a domestic fuel in cities because of its bulkiness, and the increasing use of gas. At present its chief use (in Holland) is on flat grates under boilers—the most efficient method. A large central station using step grates reports that it uses 3 kg. of peat per kilowatt hour. A plant using peat powder uses only 1.7 kg. but the cost of drying and grinding is nearly prohibitive. For small plants the suction producer is the most promising, and several makes, (German and English) gasify peat with complete success. A 50 horsepower plant reports 3.0 to 1.9 kg. of peat contains 44 per cent moisture per kilowatt-hour, as the load varied from 40 to 100 per cent. A 300 horsepower plant reports 1.24 kg. of peat containing 25 percent moisture per kilowatt-hour. It is calculated that the fuel for 1 kilowatt-hour cost 0.004 pfennig (pfennig = 0.4 cent) for peat in a suction producer, 0.007 pfennig for peat on step grates, 0.007 pfennig for anthracite in a suction producer, 0.01 pfennig for steam coal, and 0.012 pfennig for a Diesel engine.

In using Peat in a pressure producer, the opportunity of using the Mond process and recovering up to 70 per cent of the nitrogen in the peat as $(NH_4)_2SO_4$ is a great advantage. The use of the pressure producer necessitates a larger plant than the suction producer, and unless the furnishing a year's supply of fuel during the summer months, and the providing of storage place for it, are carefully considered, serious difficulties may be experienced. Large plants have been operated a short time with complete success only to be shut down because of irregular and insufficient peat supply. If such storage can be provided, the result is an extremely uniform fuel of low moisture content for the greater part of the year. Calculation are made for a plant containing two 1000 horsepower engines. It is assumed that from a ton (metric) of peat there can be obtained gas for 1000 horse-

power hours. 35 kg. $(NH_4)_2SO_4$, and 30 kg. tar. On this basis the power should cost 0.0045 pfennig per horsepower hour. This does not include the fixed charges on any electrical equipment; with these included the cost becomes 0.0083 pfennig. By assuming a little more favorable conditions, though not more favorable than have been reported from existing plants, it is calculated that 1 horsepower-year could be generated for 30. pfennigs. It is calculated that one district in Holland which has been fairly well surveyed would operate such a plant 42 years. The use of gas from such a plant in Bone-Schnabel boilers instead of gas engines is calculated as calling for a consumption of 2 kg. of air dry peat per horsepower-hour, where the same peat on step grates needs 3.3 kg.

PRESSURE CARBONIZATION OF MOIST SLIME AND PEAT.

(Ger. Pat. 283,534, Jan. 21, 1911).

The dredged or cut material is spread out upon drying surfaces, and after a varying degree of moisture has been lost, dependent upon the weather, it is brought together in low heaps, and then shoveled, the wet with the dry into heaps about 8 m. high. Heating in these heaps to 82° C., results spontaneously, and the height is reduced one-half. Even in the years with most frequent rains the moisture content is reduced to below 40 per cent, and the pressure exerted by the heap effects a degree of carbonization. The product has the consistency of briquet material, is a good fuel, and may be transported readily.

THE UTILIZATION OF PEAT.

From Engineering Supplement of London Times, April 8, 1916.

The serious increase in the cost of fuel which has occurred during the past eighteen months and the certainty that when the war is over coal will not return to its former low level of value is forcing engineers and chemists in all countries to consider the use of other forms of fuel for heating and power purposes, and the much neglected low grade fuels are at last receiving a fair measure of attention.

An interesting example of the successful utilization of peat is afforded by a scheme in Friesland, which is not only supplying electric power and light to the towns and villages around it, but is also providing current for the operation of the Ems-Jade Canal and for tramways in the neighboring towns of Emden and Wilhelmshaven. This peat bog is situated in the Duchy of Oldenburg and is known as the "Wiesmoor." The Ems-Jade Canal passes north of it, and the important dock yard town of

Wilhelmshaven is only 30 miles distant to the northeast. The places supplied with electricity from the station are Emden, Wilhelmshaven, Aurich, Bant, Norden, Oldenburg and Rustringen. The whole of the power required for cutting and transporting the turfs to the generating station, and for preparing the cleared land for agricultural operations, is provided also by the same generating company. The generating plant and distributory system have cost between $750,000 and $1,000,000 and the plant has now been in successful operation since 1909.

The power house has a capacity of 5,400 horsepower and is equipped with three turbo generators of 1,250 kilowatts, delivering three-phase current at 6,000 volts to the transformers, which raise the electro motive force to 20,000 volts for transmission purposes. Steam is supplied to the turbines from four water-tube boilers provided with stepped grates. These grates are inclined at an angle of 36 degrees to the horizontal, and are divided into two portions, each of 43 square feet superficial area. A series of traveling belt conveyors carries the peat briquets as they come from the drying grounds or storehouse to the storage bunkers, and then, after screening and weighing, they are again carried by belt conveyors to the feed hoppers over each boiler.

The calorific value of the dried peat briquets averages 5,400 British thermal units, or less than one-half that of ordinary slack. Consequently, careful regulation of the air supply is necessary to obtain a good efficiency from the boilers, and the fresh fuel must be supplied at very short intervals. Under proper conditions of combustion, however, good results are obtainable, and a steam raising test made soon after the plant was started showed a boiler efficiency of 73½ per cent and an evaporation of 3.01 pounds of water per pound of dried peat. The peat briquets in this case had a calorific value of 4,824 British thermal units. Basing the calculation upon a fuel consumption of 2.5 kilograms of peat briquets per kilowatt hour, and a cost for fuel of 5 marks per ton of briquets, it appears that the cost of the fuel required to generate one kilowatt hour at the Wiesmoor station, when it was first started, averaged 0.156 d., which compares quite favorably with the cost of fuel per unit generated in the best managed stations in this country.

No artificial heat is used in drying the peat briquets. They are stacked on cleared portions of the bog land in heaps and left exposed to the drying action of the sun and air through the summer months of the year. In this way the moisture content is reduced to 25 per cent, or one-third of that present when the peat is first dredged from the bog. The briquets when first cut measure 13 by 5 by 5 inches, and after drying shrink to 10 by 2½ by 2½ inches. In the summer the output exceeds

the requirements of the generating station, and as the peat blocks when once air dried do not readily take up more moisture from the air, they are stacked in the open and loosely covered with tarpaulin sheets until required for the boilers. A light railway upon which run small tip wagons drawn by a petrol or benzol motor is used for transporting the briquets from the drying grounds to the power house, and the success of the whole scheme is largely due to the extent to which hand labor is reduced to a minimum in dealing with the product of the dredgers.

The dredgers form the most striking feature of the installation. The whole process of dredging the peat from the bog, pulping it, and molding the pulp into briquets or "turfs" is carried out by machines worked by electric power. The dredgers are mounted on wheels, and run on tracks laid along the edge of the portion of the bog with which they are dealing. The larger type of machine was designed and built by the firm of W. K. Strange of Oldenburg, and comprises a chain bucket dredger, a belt conveyor, and a pulping press, all combined in the one machine. The bucket chain is driven by an electric motor placed at the head of the frame carrying the buckets, and a second motor placed to the left of the first causes the bucket chain to travel backward and forward in a horizontal direction, through a space of four meters, and thus to dredge away the edge of the bog to that extent at each journey. The forward movement of the whole machine is effected by hand levers under the wheels along a wood track laid down as required. The wet turf dredged from the bog by this machine contains 90 per cent of water, and is carried in this wet state by belt conveyors, running in a trough, to the pulping press, from which it issues in the form of a uniform thick pulp. It is then taken by another electrically operated belt conveyor to the drying grounds where it is cut by an electrically driven cutter into oblong blocks measuring 13 by 5 by 4 inches, and is left here until a dry crust has formed upon it, and the blocks or "turfs" are firm and hard enough to handle. The turfs are then collected and stacked by girl labor into small heaps, and are left exposed to the sun and air until quite hard, and until the moisture contents are reduced to 25 or 30 per cent.

In addition to the large dredgers of the type just described, there are 12 smaller machines at work on the Wiesmoor, designed and built by R. Dolberg & Co., of Hanover. These machines consist of an electrically operated bucket conveyor, and of a pulping and molding press. The machines are fed the wet peat by hand. The pulp issues from the press in the form of a thick, continuous ribbon 13 inches wide, and a workman

standing by the delivery chute cuts it into strips as it passes, these being carried off to the drying grounds by hand labor. According to the guarantee of the firm, one Dolberg machine in a 10 hour day can produce 60,000 to 80,000 turfs (or briquets) with the aid of a twelve and one-half horsepower motor and three laborers.

Maintenance of Peat Supply.

Progress is now mainly directed to reducing the manual labor required both in the winning of the turf from the bog and in the later processes of drying and storing the briquets, and therefore the larger Strange machines are the more favored. The combined dredging and briquet molding plant of the Wiesmoor Bog has a capacity of 30,000 to 35,000 tons of dry peat briquets during a good summer season, that is, when the weather conditions from April to August favor the drying of the turts. If the weather be cold and wet, this capacity is greatly reduced, for the briquets in such a season do not lose sufficient moisture to enable them to be handled and stored, and if frost comes before they have dried down to the 25 or 30 per cent limit they are ruined for heating purposes. Turf fibers are turned into fine dust by frost, and this dust on combustion is carried away into the flues by the draught in the furnaces and yields little heat to the water. In order to overcome the difficulties caused by a wet summer large stocks of dried peat briquets have been accumulated, some out in the open and some in covered sheds capable of housing 2,000 tons of briquets, and equal to 27 days' supply for the generating station, when running at full load. The consumption of the generating station is about 75 tons of dry briquets a day, or 25,000 tons a year of 330 working days, and in order to be quite safe as regards fuel supplies, it is arranged to have always one year's stock of dry turfs in hand.

PEAT FUEL IN GOLD DREDGING.

Gold production in the Straits of Magellan has declined greatly during the past five years, and out of a total number of 15 dredges erected at Tierra Del Fuego, one only has worked intermittently during the last three years, according to T. C. Earl in the Mining Journal, (London) of December 18, 1915. The Rio del Oro dredge is the only one now working.

It was on this field that peat was first used for developing power for steam dredges, according to Mr. Earl. In the first stages coal was used, but was found much too expensive. The potential energy locked up in the extensive peat deposits of the Oro, Oscar and San Antonio valleys are enormous, but until the last stages of dredge mining in the island was reached, about

the year 1909, little advantage was taken of this abundant and economical fuel lying close at hand. Since 1909 peat has been the only fuel used on this field.

PEAT IN ARGENTINA.

In Tierra del Fuego, the southernmost point of Argentina, are deposits of peat and lignite which are said to be of an unusually good quality. Samples of this native fuel were shown in a local exposition in 1910, and they have been tried by the army with satisfactory results. The most promising fields for supplying immediate needs, however, are the peat deposits at Carrasco, near Montevideo. A few years ago the Uruguayan Government granted a concession of 32 peat mines here for exploitation by a private firm, but the contract was not fulfilled, and the full possibilities of the mines have not yet been demonstrated. (Consular report, April 13, 1916.)

PEAT FUEL FOR RUSSIAN ELECTRIC STATIONS.

The Zemstvos Association has, says a Moscow communication, been engaged on numerous communal questions, including that of the use of the peat bogs of Central Russia, in order to replace coal, which is now so scarce and expensive for raising steam, particularly for central electric stations, which would bring into existence a great number of manufacturing concerns. It is maintained that the institution of such stations would immediately result in great industrial activity in the Moscow district, and make it independent of the South Russian Coal and Caucasian petroleum. At present the importance of electric transmission is very pressing in view of the scarcity of coal, and the disorganized railway transport system. The institution of such concerns on a cooperative basis is, however, hindered by the lack of a special law authorizing the alienation of private lands for laying electric cables and overhead lines. In connection with this question, the association is seeking to have a local application of the law ruling at Baku, with respect to the land required for laying pipe lines and such like.—(Indian Engineering.)

PEAT AS A SOURCE OF FUEL OIL.

Mr. W. H. Helm, in the Journal of the Royal Society of Arts, says that the value of peat deposits as a source of fuel has been in part known for hundreds of years, but up to recent years it has been unrecognized, even by men of science, that the greater part of that value was wasted, namely, the oil that can be produced from this material. Not only is it oil producing,

but the oil which can be, and is now being, distilled from common peat is one of the finest and purest oils that can be obtained for burning in quantities sufficient for any practical purpose. By the scientific treatment of peat, waste has now been almost completely abolished, and the peat is converted into charcoal, ammonia, acetic acid, acetone, and methylic alcohol, as well as a gas which is used, without other fuel, to heat the retorts in which the distillation of peat is carried out.

The charcoal which remains as the solid residuum, after the distillation of the peat, is of special value, in that it is not only of great heating power, but contains very little sulphur, and the oil produced in the chemical breaking up of the peat is one of the specific results of the process. On further distillation, this oil itself is subdivided into light oil, fuel oil, parraffiin wax, phenols, and pitch. The light oil is useful for internal combustion engines; the parraffin wax can be used for any purpose in which good parraffin wax is generally employed; the pitch is just pitch, and is no more or less useful than any other pitches. But the really notable result is the fuel oil. This is produced of a quality to meet the specification of the British Admiralty for naval fuel oil; and it has the immense advantage of being practically devoid of sulphur.

The absence of sulphur in a fuel oil eminently suitable for naval engines is of immense importance to the health and comfort of the engineers and firemen in all cases, and of the whole crews in the case of the destroyers and torpedo boats. The misery produced by the fumes emitted from the furnaces when the fuel contains an appreciable amount of sulphur may be readily imagined by anyone who has himself burned sulphur in a room or store for the destruction of moth, and has opened the door to see how the stuff was burning. The lungs are suffocated, the eyes are inflamed by this penetrating smoke, and the human victim feels for a time that he would rather all the germs and moths should do their worst than that he should suffer such intense discomfort. Yet the stoker in the engine room of a ship where sulphuroues fuel is burnt—as it commonly is in small, swift-going naval craft—has to endure a similar discomfort nearly all the time, and this discomfort is often shared by half the crew who happens to be employed below deck, particularly in the space behind the engines. Not only does the health and efficiency of the human factor suffer much from sulphurous fumes from the oils hitherto in use in our fleet, but the mechanical factor, the engines themselves, suffer a constant deterioration from the same cause. For every reason it is desirable that the oil containing the minimum of sulphur should be employed.

For naval purposes, therefore, not only on the score of efficiency as a fuel, but of economy of health and humanity, the peat oil is ideal. As to cost, the price at which it is already produced is satisfactory, and the price at which it will be produced when large supplies are demanded, and great quantities of peat are brought under treatment, will be considerably less than it is in the present circumstances of restricted manufacture.

The supply of the raw material is practically inexhaustible. It is true that, in spite of the fact that the neglect of all but the surface peat, has up till recently, left the lower masses to become richer year by year in those constituents from which oil is now being produced, there has been an appalling waste during centuries past; but there should be waste no longer. The peat moors of Scotland, of Northern England, of Ireland, and Wales, and of France, where vast tracts of peat lie about La Vendee, for instance, and in other regions well known to specialists in the new process, will almost certainly be brought under the control of the men who will know how to develop to the utmost for national purposes these rich gifts of nature hitherto so lavishly misused.—(The Colliery Guardian, Vol III, Feb. 4, 1916, page 220.)

UTILIZATION OF PEAT TAR.

(G. T. Morgan and G. E. Scharff, Econ. Proc., Dublin Soc., 1915, vol. 2, p. 161.)

The destructive distillation of peat in retorts, producer gas plants, etc., yields a tar which on subsequent distillation gives neutral oils differing from the aromatic oils of coal tar and from the parraffins in being highly unsaturated, as shown by the rapid manner in which they absorb atmospheric oxygen. Alkaline extraction of these oils separates oils of high boiling point and powerful germicidal power; these oils are sparingly soluble in water, and may be used in aqueous suspension, emulsified by admixture with gum acacia mucilage, castor oil soap, etc., or as solid disinfectants mixed with hard soap, dextrin, etc. Small amounts of basic substances of the pyridine group are present in the crude peat tar oil. The higher fractions of the neutral oils are waxes similar to the montan wax of lignite. The residue from the distillation of peat tar is a typical soft pitch, which could be used as asphalt, caulking material, or for electrical insulators. A sample of the crude tar contained 29.3 per cent moisture, 52.6 per cent volatile oils and waxes, 5.8 per cent pitch, and 11.7 per cent solid matter.

GAS FROM PEAT.

(G. A. Brender, A. Brandis, Jour. Gas Light. vol. 132, 1915, p.94.)

Experiments were made upon two sorts of peat (heavy lumps and small lumps) in a horizontal retort. The gas contained 13 per cent CO_2, 2.1 per cent heavy hydrocarbons, 23.8 per cent CO, 12.1 per cent CH_4, 39.6 per cent H, and 8.7 per cent H_7, and had gross calorific value of only 366 B.t.u. Roughly, 17,500 cubic feet of such gas was produced per metric ton of peat, and 0.402 ton of wet coke of poor quality. It was found that the most practical way of carbonizing peat was to mix it with 80 to 90 per cent of English gas coal. This treatment increased the yield of gas from 10,000 cubic feet per ton for 100 per cent coal to 12,700 cubic feet for 80 per cent coal and 20 per cent peat. The quality of the coke was fairly good in this case, and the calorific value of the gas was hardly affected.

Peat Powder Used by Sweden for Locomotives. Experiments in the use of peat powder on locomotives of the State railway have demonstrated that as heavy trains can be pulled and as good speed be made where this fuel is employed as where anthracite coal is used, according to a statement issued by the Swedish telegram bureau, which has been received from the secretary of the American Embassy at Stockholm. The statement declares that the powder can technically, as well as economically, take the place of anthracite as fuel for locomotives.

The railway directors have decided to undertake the development of this class of fuel by two different methods for purposes of comparison. Two experts have been requested to give complete estimates of the cost of preparing a certain bog for the manufacture of peat powder, together with estimates of running expenses, by the respective methods. The bog selected is said to be that at Hasthagen, about one and one-half miles from the station at Vislanda, with an area of about 500 acres. (Consular report, Feb. 17, 1916.)

Demand for New Peat Fertilizer in England. The commercial demand for humogen, the new peat fertilizer that is being experimented with in the United Kingdom (see this Journal Vol. 9, p. 120) is already greater than the supply, according to a report published by the Canadian Department of Trade and Commerce. Offers at $73 per long ton are being made, but the plant available for producing the fertilizer is limited. The report says further:

Experiments at Kew Gardens and at an experimental station in the Lea Valley have given some remarkable results. Plants seemingly dying have been restored to more than normal growth. Four potato sets weighing a few ounces in all, placed in a small box of moss litter and watered once a week with the extract from bacterized peat, produced 3 pounds of potatoes in eight weeks. One tomato plant so treated had 16 pounds of tomatoes on it at one time. At the experimental station in the Lea Valley 18 cucumber plants treated with manure and bonemeal yielded 484 pounds of fruit. Eighteen other grown in 9 parts of ordinary soil mixed with 1 of bacterized peat, gave 644 pounds of fruit, and marketed 71 pounds before a single cucumber was ready from the other crop. (Consular report, Feb. 12, 1916).

Peat Fertilizer for Manchester's Waste Lands. According to the Manchester Guardian, Prof. Bottomley of King's College, London, has offered to the city of Manchester a free license for the preparation of the bacterized peat fertilizer (see this Journal vol. 9, p. 120) during the period of the war. He has also offered to provide the necessary cultures of bacteria for the accomplishment of the work, provided that the Manchester Corporation undertake the preparation of the fertilizer within three months and in specified quantities. Manchester owns extensive peat lands and also waste lands that could be fertilized. The acceptance of Prof. Bottomley's offer depends upon the reports of several Corporation committees. (Consular report, Feb. 16, 1916.)

The municipal authorities of this city at a meeting held on February 9 accepted the special committee's proposal to undertake the experimental manufacture of bacterized peat, or "humogen'" subject to satisfactory arrangements being made with the discoverer, Prof. Bottomley. The experiments to be made are stated not to cost more than $2,433. The city authorities have 130 acres of raw peat which they cannot at present cultivate. If the plan succeeds the peat will become a valuable asset to the municipality. It was claimed by one of the city councilors that the treated peat is a commercial success, and can be sold at a good profit. (Consular report, Mar. 4, 1916).

The peat lands referred to in the above consular report are the Chat Moss bog of which we understand the Manchester Corporation owns 2,500 acres.—H. P.

GAS FROM PEAT.

(N. Testrup, T. Rigby, and O. Soederland, U. S. Pat. 1,164,429, Dec. 14, 1915).

A fluid pulp of peat is heated under pressure to above its normal boiling point, the pressure being sufficient to prevent boiling; it is immediately filter pressed and dried in a current of hot gases, briquetted, and converted into fuel gas, from whch ammonia may be recovered.

PEAT FERTILIZER.

(T. Rigby and Wet Carbonizing, Ltd., Br. Pat. 18558, Aug 11, 1914).

Ammonia is absorbed, from gases such as those obtained in peat gasification, by means of peat which has been subjected while wet to a heat treatment which renders its water readily expressible. The peat containing ammonia is suitable for use as a manure.

(Peat humus treated with ammonia and nitrogen compounds has since several years been on the market in this country as a soil dressing and manure.—H. P.)

PEAT SOIL DRESSING.

(N. Testrup, T. Rigby and Wet Carbonizing Ltd., Br. Pat. 18838, Aug. 19, 1914.)

A dressing for soils is prepared by subjecting peat while wet to a heat treatment at a temperature of at least 60 degrees C., without evaporation, to render its water readily expressible. The treated peat may be caused to absorb ammonia.

BRIQUETTING PEAT DUST.

(Emil Schimansky, Ger. Pat. 289070, Nov. 22, 1914).

This is a supplement to German Patent 287157, (see this Journal, vol. 9, p. 127). and has for its purpose the increasing of the hardness of peat dust briquets by adding coke dust to the peat dust and heated sawdust.

BY-PRODUCTS FROM PEAT BY A DESTRUCTIVE DISTILLATION.

(Franz Brunck, Ger. Pat. 289,519, Dec. 13, 1913).

The raw gases are first passed into a heated apparatus containing lime, then through scrubbers and washers which separ-

ate the tar, and ammonia salts, and finally through an apparatus to absorb the free ammonia.

DEWATERING PEAT BY MECHANICAL MEANS.
(T. A. Lindeber, Ger. Pt. 290,022, Mar. 11, 1914).

The dewatering apparatus turns round a vertical shaft, and consists of partitioned baskets provided with tangential air tubes and stirrers, the water being separated by centrifugal force. The circular baskets have a concentric air blast against which the peat is pressed.

LIQUID HYDROCARBONS FROM PEAT BY USING THE ELECTRIC ARC.

(G. Tischenko and H. Plauson, Ger. Pat. Application T 17913, 12, Handed in Oct. 26, 1913.)

Peat is mixed with metals, metal salts, or oxides and treated with an electric arc, the evolved gases, after separation of the liquid hydrocarbons, are passed through a tube at dull red heat, preferably in the presence of catalysers.

Journal of the American Peat Society

VOL. IX — OCTOBER, 1916 — No. 4

BACTERIZED PEAT

During the past year much information and many reports have emanated from various sources regarding the wonderful properties of bacterized peat. Hence it is perhaps our duty to explain briefly the possibilities of such products. In fact, the daily newspapers occasionally report that unforeseen yields have been created by the use of this bacterized soil.

Late in the last century it was discovered that certain organisms in the soil were able to use atmospheric nitrogen and convert it into nitrogen compounds which were then assimilated by certain plants through their roots, their yield and growth being thus considerably increased. In fact, certain plants would be unable to grow were it not for the activity of soil bacteria. However, the discovery of the presence of these nitrifying bacteria opened new potentialities to the scientific agriculturists, and today products containing these bacteria are being intelligently commercialized for the benefit of the farmer. Up to a few years ago little success had been obtained in endeavoring to put on the market a product inoculated with these bacteria, until it was discovered that peat formed an ideal medium for carrying the bacteria.

Professor Bottomley conducted numerous experiments at Kew Gardens, England, with bacterized peat, and obtained some remarkable results. These results have, from time to time, been reported in this Journal. Several agricultural stations and agriculturists have used bacterized peat, some reporting excellent results, others reporting indifferent results, and some reporting negative results. Why this discrepancy?

The popular mind was so engrossed with the results reported from successful tests that many persons concluded that

the application of bacterized peat soil was all that was necessary to increase agricultural yields.

Bacterized peat, like any other agricultural fertilizer, requires intelligent application, and the bacteria alone will not solve the fertilizer problem, but these together with proper material undoubtedly form an ideal fertilizer for certain crops. As we have already reported, the municipal authorities of the city of Manchester are manufacturing bacterized peat according to Professor Bottomley's patents, and one cannot be surprised when they state that purchasers of this bacterized material receive no guaranty of the fertilizer value in any way, which shows that results from this material cannot be guaranteed unless it is used with some intelligence.

Previous to the war in Europe Professor Bottomley refused full information as to his process, but has now given his processes free to his nation. In this country, for some considerable time, work on bacterized peat has been under investigation; perhaps some of the most intelligent work in this line is being carried out by Professor Manns, of Delaware. Previous work by agricultural bacteriologists has shown that nodule bacteria of all the legumes are included in six or seven physiological species and from these it was simple to make one compost a carrier of all these organisms. Experiments were then conducted to correct any objectionable qualities in the carrier, and to develop satisfactory methods of inoculation. Furthermore, preparations have been carefully tested for the different legumes and we hope in a short time to publish in this Journal the results of experiments conducted at the Delaware College.

In addition to all this work the effect from a biochemical standpoint has had to be studied and it has been ascertained that an action exists, which consists of making phosphorous and calcium compounds soluble by bacterial oxidation and a conversion of ammonia into nitrites, and the former is of as much importance to the agriculturists as the nitrogen end itself, because bacteria alone will not act in the most beneficent sense, the plants requiring also other requisite food changed from its insoluble and weakly active state to a condition in which it can be assimilated.

Although previous to the war German agriculturists were anxious to obtain information from Professor Bottomley, he refused it to them as he had refused it to others. However, in the meantime, undoubtedly, the German scientists have gone ahead and conducted experiments. Thus, we read the following in one of the German agricultural papers regarding Professor Bottomley's work:

"The utilization of bacteria to convert certain organic substances into a soluble form and at the same time to bind the

free atmospheric nitrogen is not 'hot air' but is in principle correct, as has been corroborated by German scientists. At the same time we should be skeptical regarding the reports of the wonderful results obtained by 'Humogen,' especially as our authorities did not pay much attention to it in June, 1914. In the meantime, however, our agricultural bacteriologists will certainly have given Humogen closer investigation to arrive at definite conclusions."

Successor to Professor Davis. It is questionable whether the U. S. Bureau of Mines will be able to continue the peat investigations formerly conducted by the late Prof. Chas. A. Davis, on account of the limited funds at its disposal. A bill has recently been introduced in Congress providing for an investigation of the lignite deposits of the country by the Bureau of Mines. If a special appropriation were to be made for this work, a considerable amount of study would necessarily be given to the subject of peat and, in that event, a peat expert would be appointed.

Prepared Peat Development in Chile. The fuel problem in Chile is becoming more and more acute. The local coal mines can take care of hardly 50 per cent of the demand, trains have been taken off schedule because of lack of coal, and experiments are being made with wood as a possible substitute for coal on the railways. For this reason influential parties are desirous to work the peat deposits as early as possible. Peat is located near Santiago, on the railway line, and is found at a depth of about 5 feet.

TECHNICAL ACTIVITIES OF THE GERMAN PEAT SOCIETY IN 1915.

Director Arland reports that the technical division of the German Peat Society was greatly handicapped on account of the war. The great object was to use the increased production of peat coke for firing boilers and other heating devices, to take the place of the previously used fuels, as it was desired to gain the valuable by-products from dry peat distillation, such as ammonia, tar, benzol, and toluol. Details regarding the work of Arland will be presented in one of our next issues.

The utilization of fibrous peat in pressed plates or blocks for insulating and sound-proofing material, instead of cork, has found considerable application and peat in such form has been adjudged as a very good substitute.

Is Dewatering Peat By Machinery Commercially Practicable?

By G. Herbert Condict, Plainfield, N. J.

In discussing this question, I have necessarily been confined to my own personal experience, as up to the present I have been unable to secure data from other investigators in this important field.

During the past four years extensive experiments have been in progress, with the object of finding an answer to the above question, which is so vital in the commercial development of the peat industry in this country. At past conventions of the American Peat Society, I have referred to these experiments in a general way, always hoping that at the next meeting I would be in a position to give not only a definite answer, but also a detailed description of the apparatus used in the work.

A definite affirmative answer can now be given, but unfortunately it is somewhat too early to give a description of the machine.

A dewaterer of commercial size has been completed and operated, as far as operation can be carried on under shop conditions.

We are now endeavoring to arrange for commercial operation on a bog, where the capabilities of the dewaterer can be amply determined.

The capacity of this dewaterer is approximately 11 tons per hour of wet peat, which at 90 per cent moisture content, will give a product of 1⅓ tons of 15 per cent peat per hour after passing through a dewaterer and dryer.

As stated in former communications, this dewaterer is primarily designed to be operated in a wet bog, in connection with a dredge and dryer, the whole equipment being installed on a lighter or lighters, and floated around from place to place, no stationary plant being necessary.

Two or more dewaterers and dryers will be installed on a suitable hull, with dredge on the same hull, or separate.

The wet material will be deposited by the dredge directly into the hopper of the dewaterer; from thence it will pass by conveyor into the dryer, to be delivered from the other end into a storage barge; the whole operation from bottom of bog to storage, or from wet peat to finished product, requiring less than half an hour.

From 1 ton of 90 per cent peat the dewaterer will extract 1350 pounds of the contained 1800 pounds of water, leaving 200 pounds of peat and 450 pounds of water, or material of about 70 per cent moisture content.

This material is not caked, but in a mealy condition—most advantageous for drying. The dryer will evaporate about 415 pounds of the remaining moisture, leaving the 200 pounds of peat and 35 pounds of moisture, or 15 per cent peat, in condition to be used alone, or in connection with other ingredients, as a valuable fertilizer.

The peat will pass automatically from the bottom of the bog to the storage lighter without the aid of direct labor other than that required for dredging and firing, and necessary inspection to determine that all parts of the equipment are functioning properly.

Outside of the power for dredging, the power needed for operating the entire plant will not exceed 40 horsepower.

The dryer will require 400 pounds of coal, or equivalent, per ton of finished product. The apparatus is simple and reliable, so that the cost of repairs will be slight.

The labor question, such a vital factor in many parts of the country where bogs exist, will be largely solved.

Weather conditions will not affect the operation of the plant, and work can be carried on at night as well as in the day.

It is expected that bogs now dry can advantageously be worked by this system, by starting the plant in a hole containing a sufficient amount of water to float the lighters.

And so I would most emphatically say "YES" in answer to the question which is the subject of this paper, and possibly there are dewaterers that have been developed by others, which will aid, along the lines mentioned, in making of the peat industry far more of a commercial success in this country than it has been up to date.

PEAT IN IRELAND.

On May 9th Mr. Ginnell, M. P., asked in the British House of Commons whether the department of agriculture, with a view of founding and working peat industries in Ireland after the war, was obtaining information relating to processes, machinery, methods and results of such industries in Russia, Sweden, Denmark and Holland, and whether the House proposed to form a national peat committee to deal with the possibilities of bog development in Ireland. Mr. Russell answered that the House was in communication with the department on this subject but it was not the intention to form a committee of the nature referred to.

THE FUEL QUESTION IN SWEDEN.

The peat fields of Sweden cover an area of 4,000,000 hectares (9,884,180 acres), but only a limited area is in proper condition to be utilized. The annual production of peat does not exceed 62.000 tons, but with coal selling at 62.50 crowns ($16.75) per ton as at present, the question of producing cheaper fuel is an absolute necessity, and to that end it has been decided to erect a factory in southern Sweden for the manufacture of powder peat fuel, which is adapted for industrial purposes. The project has been recommended by the Bureau of Commerce and approved by the Department of Agriculture, and will receive state aid to the extent of 500,000 crowns ($134,000).—Consular Report, May 24, 1916

1914 PEAT PRODUCTION IN CANADA

Only one peat bog was operated in 1914, viz: that of the Canadian Peat Company (Head Office, Kent Bldg., Toronto), at Alfred, Prescott County, Ontario.

The shipments of peat during the year were 685 tons valued at $2,470, as compared with a total of 2,600 tons valued at $10,100 in 1913.

Statistics of the annual production of peat since 1900 are given in the following table:

Annual Production of Peat in Canada.

Calendar Year	Tons	Value
1900	400	$1,200
1901	220	600
1902	475	1,663
1903	1,100	3,300
1904	800	2,400
1905	80	260
1906	474	1,422
1907	50	200
1908	60	180
1909	60	240
1910	841	2,604
1911	1,463	3,817
1912	700	2,900
1913	2,600	10,100
1914	685	2,470

Bacterized Peat. Two different kinds of bacterized peat were sent to Woburn in 1915, one lot being moister, more fibrous, darker, more like litter, and containing a much larger proportion of nitrogen soluble in water.

Pot experiments were carried out in 1915 on oats, peas and mustard, the moist peat being used at the rate of 17.8 and 35.6 tons per acre (1:9 and 1:19 as recommended by Professor Bottomley). With oats, the nitrogen in the bacterized peat was compared with that in nitrate of soda, the latter having to be applied at the rate of 10.45 and 20.9 cwt. per acre; there was very little difference between the two manures as regards yield of grain, but the bacterized peat produced a marked increase of straw. Owing to the unsatisfactory germination of the peas with the bacterized peat treatment, no conclusions could be drawn as to weight of grain, but there was again a marked increase in the green portion of the plant. With mustard, a very clear advantage was gained by the peat treatment over the nitrate of soda.

Field experiments were carried out on oats, both kinds of bacterized peat being applied at the rate of 5 cwt. per acre; the drier kind did not do as well as when no treatment was given, while the moister kind did better. The value of bacterized peat for farm crops has yet to be established.—Jour. Board of Agriculture, vol. 23, 1916, p. 271.

Reclamation of Bog Land. From the results of both pot and field experiments carried out during the past three years it is evident that lime is the "limiting factor" in the reclamation of Irish bogs; in fact, it appears useless to attempt their reclamation without lime. Phosphate proved next in importance to lime. Nitrogen also proved necessary, notwithstanding the large amount in the peat. As long as the crops were producing leaf and stem only, potash was the least important of the four ingredients, but its influence was most marked in filling the grain and stiffening the straw in the case of rye and of increasing the yield of tubers in the case of potatoes.—Jour. Board of Agriculture, vol. 23, 1916, p. 271.

Bacterized Peat. The first supplies of bacterized peat, manufactured by the Manchester Corporation, under Professor Bottomley's patents, are now ready for distribution, the prices being fixed at $25 per ton in bags, and $20 per ton for two to four-ton lots in bulk at works. This fertilizer is supplied through the Cleansing Department, Town Hall, Manchester, Eng. (See also this Journal, vol. 9, p. 182.)

Peat in Spain. The scarcity of coal due to the war in Europe is evidently being felt very much in the neutral countries of Europe and South America as will have been noticed by the frequent paragraphs in our Journal on this subject. Our latest attention has been called to the poor supply in Spain. In Spain,

however, they are producing a lignite coal, since English coal has risen in price, which has been pushed with some success.

In Asturias, Santander, and Soria, peat is found, but little attention has been paid to it thus far.

Peat Culture in Germany. The Journal of the Board of Agriculture (vol. 23, 1916, p. 402), reports that efforts are being made in Germany to increase the growing of vegetables on moorland. At a meeting on February 20 last, the German Moor Culture Union decided on a policy of model vegetable gardens on moors. Manures, seeds, plants, plan of cultivation, and advice are to be supplied free to demonstrators, and grants are to be given in aid of the cost of enclosing and pumping; the demonstrators are further to receive 60 cents to $1 per square yard remuneration, and the crops will remain their property. They must follow instructions as to cultivation, manuring, seeding, planting, weeding, spraying, and harvesting.

According to notice in the Deutscher Reichsanzeiger of May 18, the Moor Culture Union has decided to grant allowance to wounded agriculturists and others who wish to take up moor culture, for the purpose of obtaining training.

Blueberry Cultivation. Several years ago it was found that certain physiological peculiarities of the blueberry plant showed that it differed fundamentally from the ordinary plants of agriculture. When given the kind of care, protection, and nourishment usually bestowed on cultivated crops, the blueberry sickens and dies.

In a search for the cause of this peculiar behavior it was found that the healthy blueberry plant has on its roots a minute fungus, invisible without the aid of a compound microscope, which, unlike most fungi, appears to be beneficial, not injurious, its particular beneficent action being to furnish nitrogenous food to the blueberry bush. So intimate, indeed, is the relation between the two that the blueberry appears unable to nourish itself properly without the assistance of the fungus.

The problem of blueberry culture, therefore, became primarily the problem of growing the blueberry fungus, and the solution of this problem lay in the character of the soil. The blueberry fungus requires an acid soil, and it thrives best in one composed of leaf peat and sand. The pine barrens of New Jersey afford just the kind of soil, with every variation in moisture from permanent bog to areas of pronounced aridity.

The failure of earlier experimenters, and there have been several in the past 50 years, to establish an industry of blueberry culture was due primarily to their failure to recognize that an

acid soil is the first essential of successful blueberry production. —F. V. Coville, Nat. Geo. Mag., 1916, vol. 29, p. 535.

Peat Gasification in Holland. On account of the scarcity of fuel in Holland, E. C. Verschoor, of Holland, has considered the question, In which way can Holland supply its own mechanical energy from its own natural resources? He comes to the conclusion that peat for boiler firing with hand stoking cannot compete with the imported fuel, because of the effect of the moisture content and also the variable composition of the peat. However, he concludes that these defects can be somewhat minimized by gasification of peat in a generator, and that this is the only way that peat as fuel can be economically used.

Dutch Maximum Prices for Peat. Commercial Attache Erwin W. Thompson, at the Hague, reports that the Netherlands Government has established maximum prices for peat on account of the scarcity and high price of coal. The development of peat beds is becoming extensive, and the establishment of maximum prices was for the purpose of protecting the poorer people against exorbitant prices for this good substitute for coal.

HEAT VALUES OF FUELS.

Kind of Fuel	Heat units per pound	Relative values	Pounds of water evaporated per pound
Carbon, pure	14,500	1.000	15.00
Hydrogen	62,500	4.280	62.75
Marsh gas	26,415	1.816	26.68
Olefiant gas	21,328	1.466	21.54
Coal, anthracite	14,833	1.020	14.98
Coal, bituminous	14,796	1.017	14.95
Coal, lignite dry	10,150	0.7	10.35
Peat, kiln dried	10,150	0.7	10.25
Peat, air dried	7,650	0.526	7.73
Wood, kiln dried	8,029	0.551	8.10
Wood, air dried	6,385	0.439	6.45
Charcoal	13,500	0.93	14.00
Coke	13,620	0.94	14.00
Petroleum, West Virginia	18,300	1.255	18.80
Petroleum, Pennsylvania	18,050	1.24	18.60
Petroleum, Ohio	18,450	1.27	19.05
Petroleum, Asia	18,000	1.24	18.60
Petroleum, Europe	18,000	1.24	18.60
Animal fat	9,000	0.65	9.30

—Power, 1916.

Land Drainage by Means of Pumps. (S. M. Woodward, U. S. Dept. Agri. Bul. 304.) Numerous tracts in units of 5,000 to 20,000 acres have been reclaimed along the Illinois River and on both sides of the Mississippi in the States of Illinois, Iowa, and Missouri. In the average district the cost of the general drainage improvements, including levees, ditches and pumping plant, has been about $30 per acre. This method of reclamation may be expected to be extended constantly to new localities as agricultural land becomes more valuable.

The design and construction of the levees, ditches, and pumping plant require a considerable degree of engineering ability. Poor design may result either in a system so inadequate for its purposes as to render the benefit to the land insufficient to make the undertaking profitable, or it may lead to an expenditure for construction greatly in excess of the amount that could have been made to suffice. In general, the inexperienced tend to underestimate greatly the extent and expense of the work required in such reclamation.

The levees must originally be made of such height and thickness as to afford ample strength and they must also be given careful subsequent attention to secure proper maintenance. The internal drainage ditches should be deep enough to keep the ground-water level at least 3 feet below the surface and their capacity should be sufficient to discharge heavy rains freely to the pumping station. Streams entering the district from higher ground should be diverted around the levees where such a plan is feasible, and provision should be made in such diversion ditches for the collection and storage of silt from hill streams.

The pumping plant should have a capacity sufficient to remove as a minimum amount in 24 hours a quantity of water sufficient to cover the entire district to a depth of 0.3 inch. The capacity should be greater in situations of heavy rainfall and where the run-off of rolling land is received in the district.

The pumping machinery should be so arranged as to reduce to a minimum the work of disposing of the surplus water, and it should be chosen with especial regard to economy and efficiency in operation. Where large fluctuations in the river level are to be expected the machinery must be sufficiently large to operate at the maximum head, and at the same time must be as efficient as practicable for more moderate heads.

As it has been shown that the average depth of water to be pumped from such districts per year will be about 15 inches, with well-designed and carefully operated plants the total cost per acre of drainage area per year should not exceed 80 cents for a mean lift of 5 feet, or $1.20 for a mean lift of 10 feet.

The administration of the business of the district should be placed in the hands of a competent engineer who is familiar with drainage work. He should be held entirely responsble for the proper administration of the district business, especially for the operation and maintenance of the pumping plant. Reliable, skilled attendants should operate the pumping plant under expert supervision and should maintain it in first-class condition the entire year. Full records of the operation of the pumping plant should be kept, as well as detailed classification of expenditures, so that those in charge can determine at all times whether the operation of the plant is as economical as may be possible while securing the results desired from the plant.

Where practicable, gravity outlet sluiceways should be installed in connection with a pumping plant for use during times of low water outside of the drainage district.

The reclamation for agricultural purposes of river bottom lands lying so low that they are subject to serious injury by overflow has been proved by experience in this country and in Europe to be feasible and profitable where the land is of sufficient fertility and where the improvements consist of a system of protective levees supplemented by interior drainage ditches and a suitable pumping plant to remove excessive precipitation which may fall within the district. Such results, however, can come only when the entire plant is properly designed and efficiently maintained and operated.

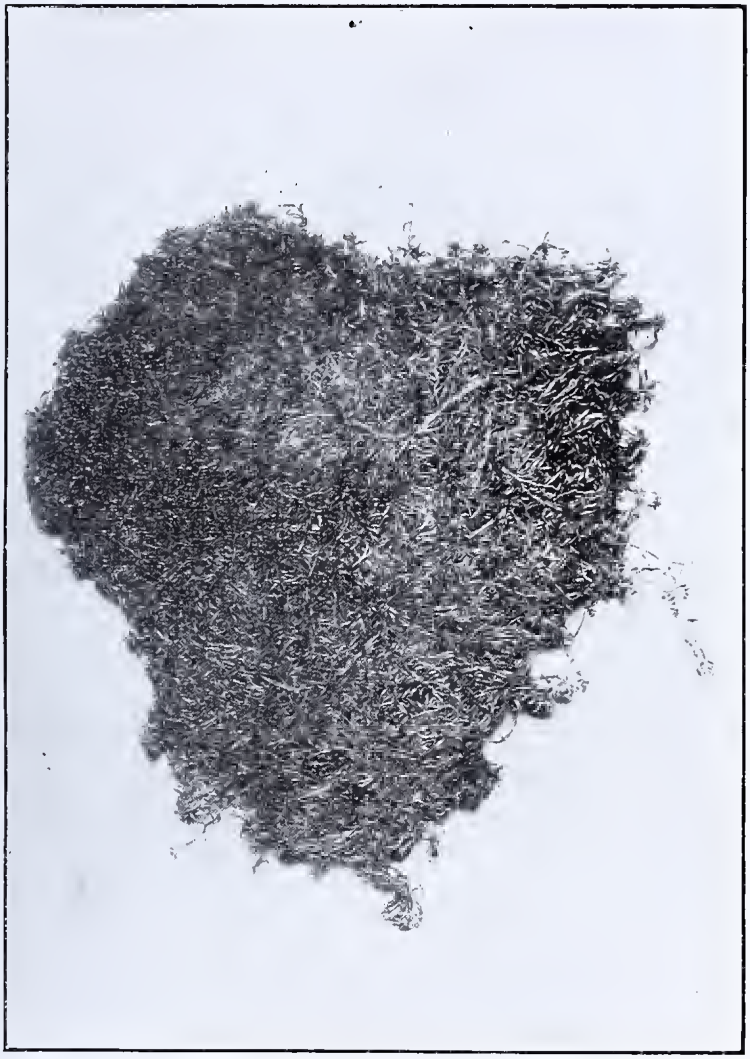
Alcohol from Peat. (E. Gazagne and R. de Demuth, Fr. Patent 477,077, May 23, 1914.) Peat, sawdust, or similar material, is saccsharified by heating under pressure with mineral acid, and then systematically extracted with hot water or vinasse in a battery of extraction vessels. To insure a good fermentation, complementary saccharifiable matters, relatively rich in nitrogen and phosphorous, are added to the charge in the autoclave, or they may be saccharified separately and added to the juice after extraction. Before fermentation the juice is neutralized solely or in part with ammonium or alkali hydroxides or salts. The yeast employed is specially acclimated to juices from cellulosic materials containing tannins.

CANADIAN PEAT BOGS

The Investigations of the Peat Bogs and Peat Industry of Canada, 1911-1912 and 1913-1914," published by the Department of Mines, Canada, from the pen of Aleph Anrep, are so thorough and interesting that, with the consent of the Dr. E. Haanel, Director of the Mines Branch, who has kindly loaned us the plates, we are publishing some of the illustrations; these illustrations show the numerous plants that go to make up the peat bog.

These reports, comprising Bulletins 9 and 10 respectively, represent the finest botanical work on peat yet published, and will be of enormous assistance, after being botanically classified, in determining for what use a peat bog can be best utilized and probably assist in determining its age.

The cuts are so numerous that we are unable to publish them all, but we have selected those that we think represent the plants most generally found.



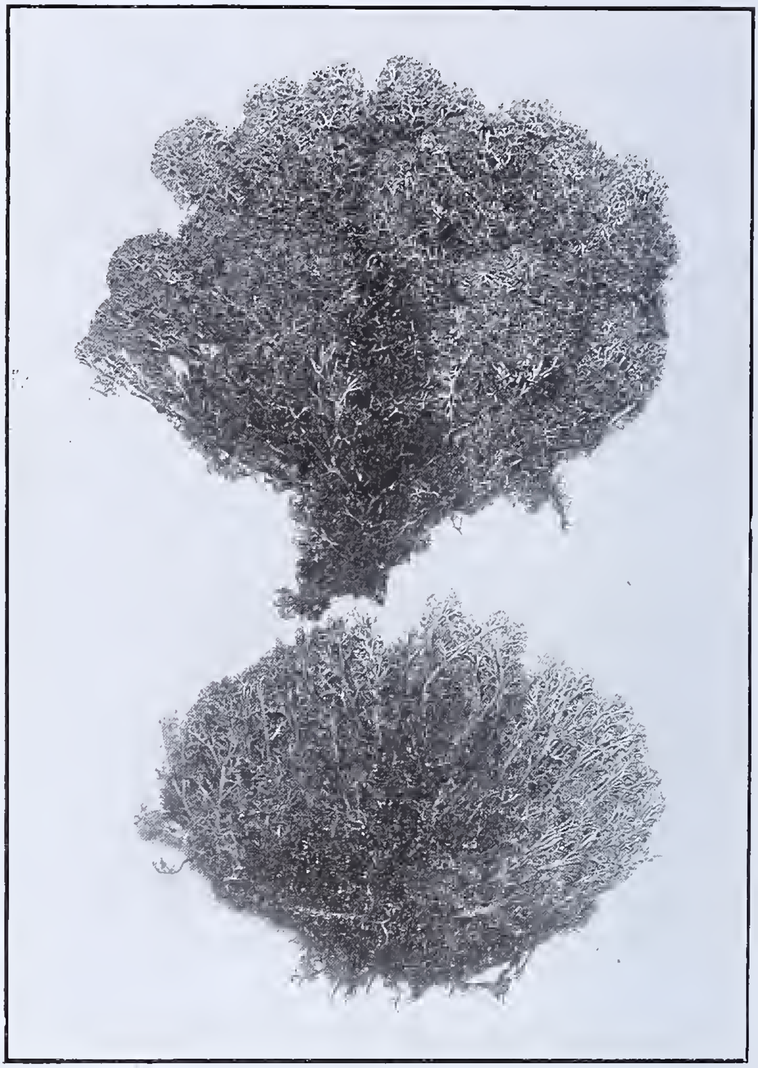
Sphagnum acutifolium.

Alisma plantago acquatica. (L.)

Iris versicolor. (L.)

Carex riparia. (W. Curtis)

Cummune polytrichum.



Cladonia rangeferina.

Bœmus æruginosus.

Carex exilis (Dewey).

Carex Brunnescens (Poir).

Scirpus Hudsonianus (Fermal).

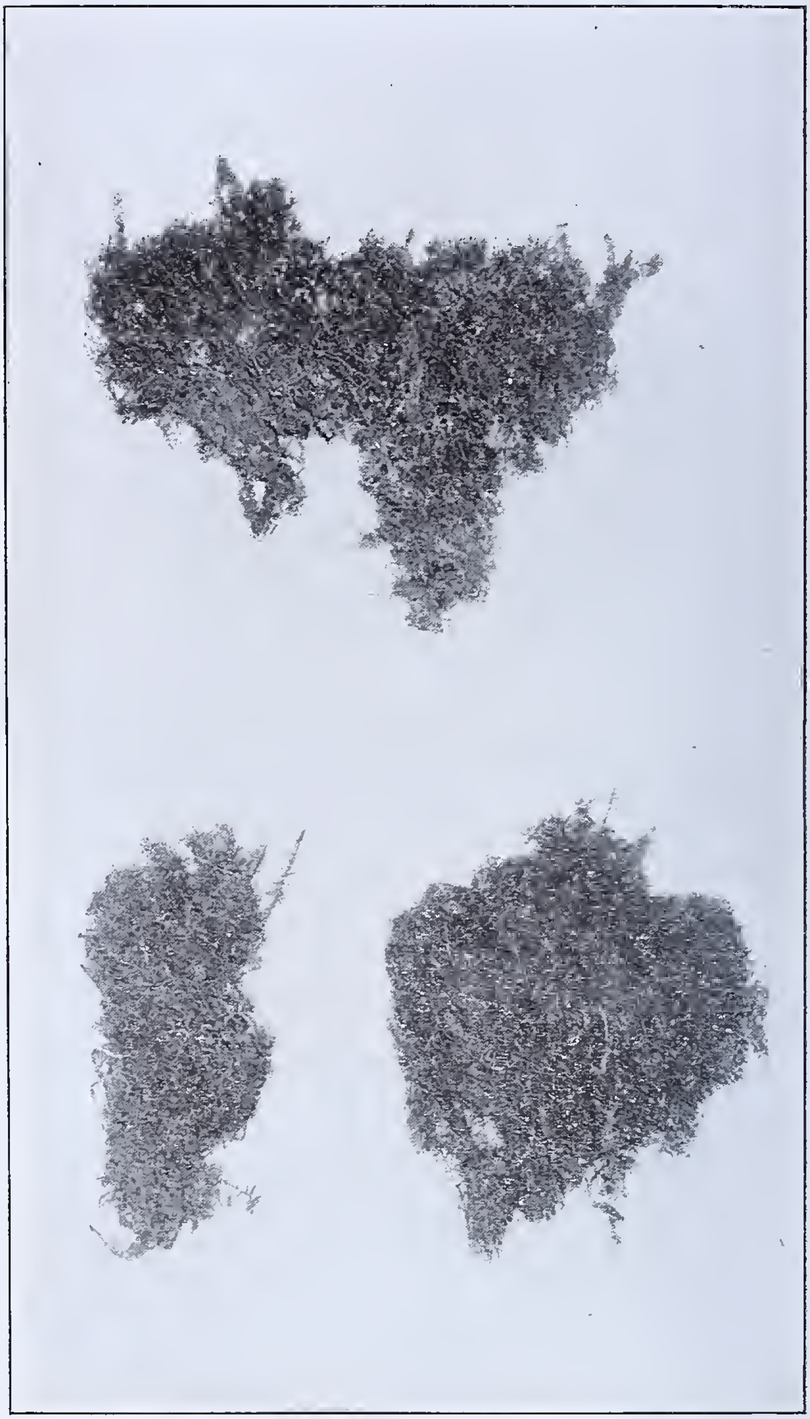
Thalictrum dioicum.

Drepanocladus Kneiffii (Sch.) Warnst.

Mnium affine, Bland, var. rugicum (Laur.) Br. and Sch.

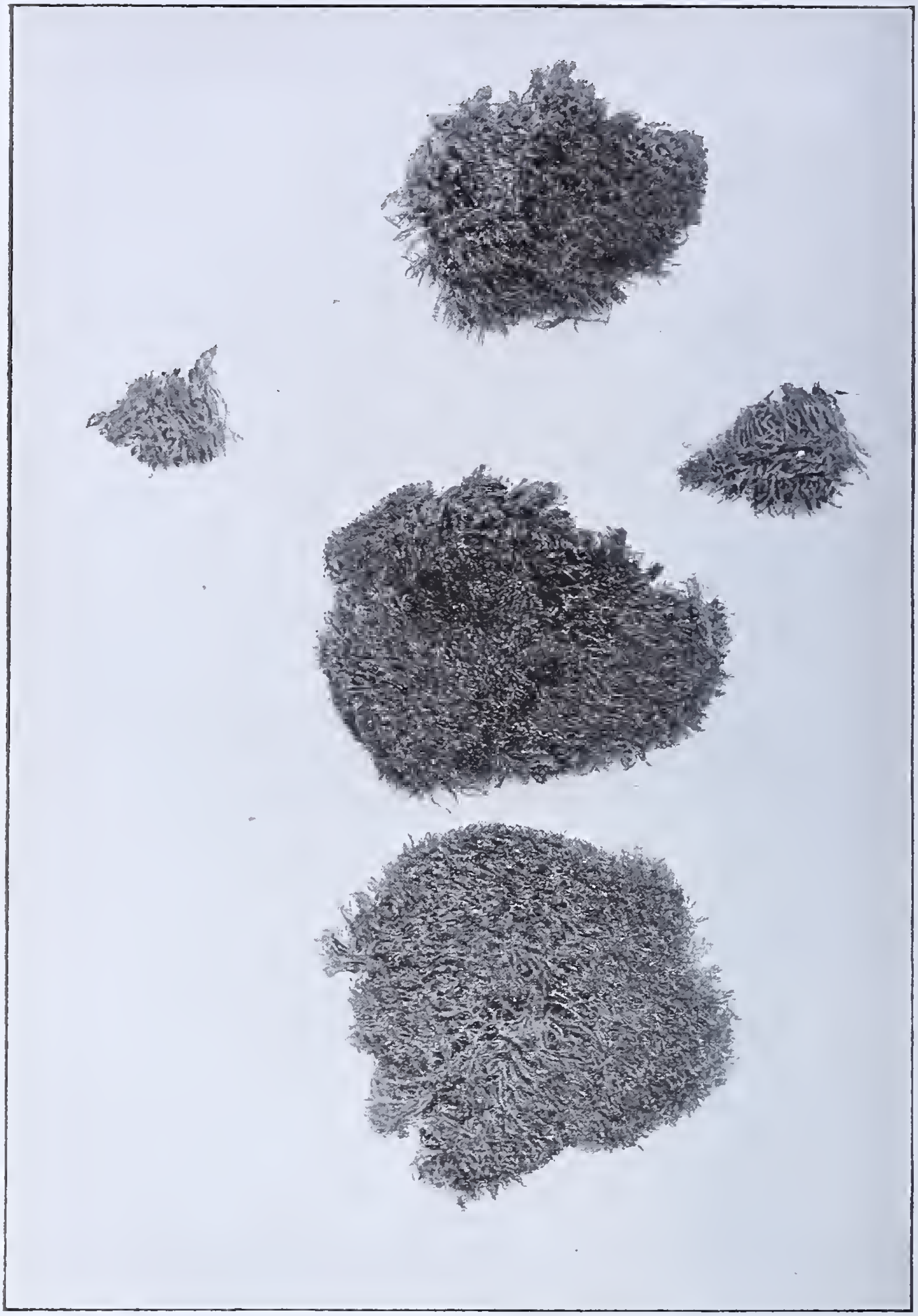
Climacium dendroides (Dill. L) W. and M.

Calliergon cordifolium (Hedu) Lindb.

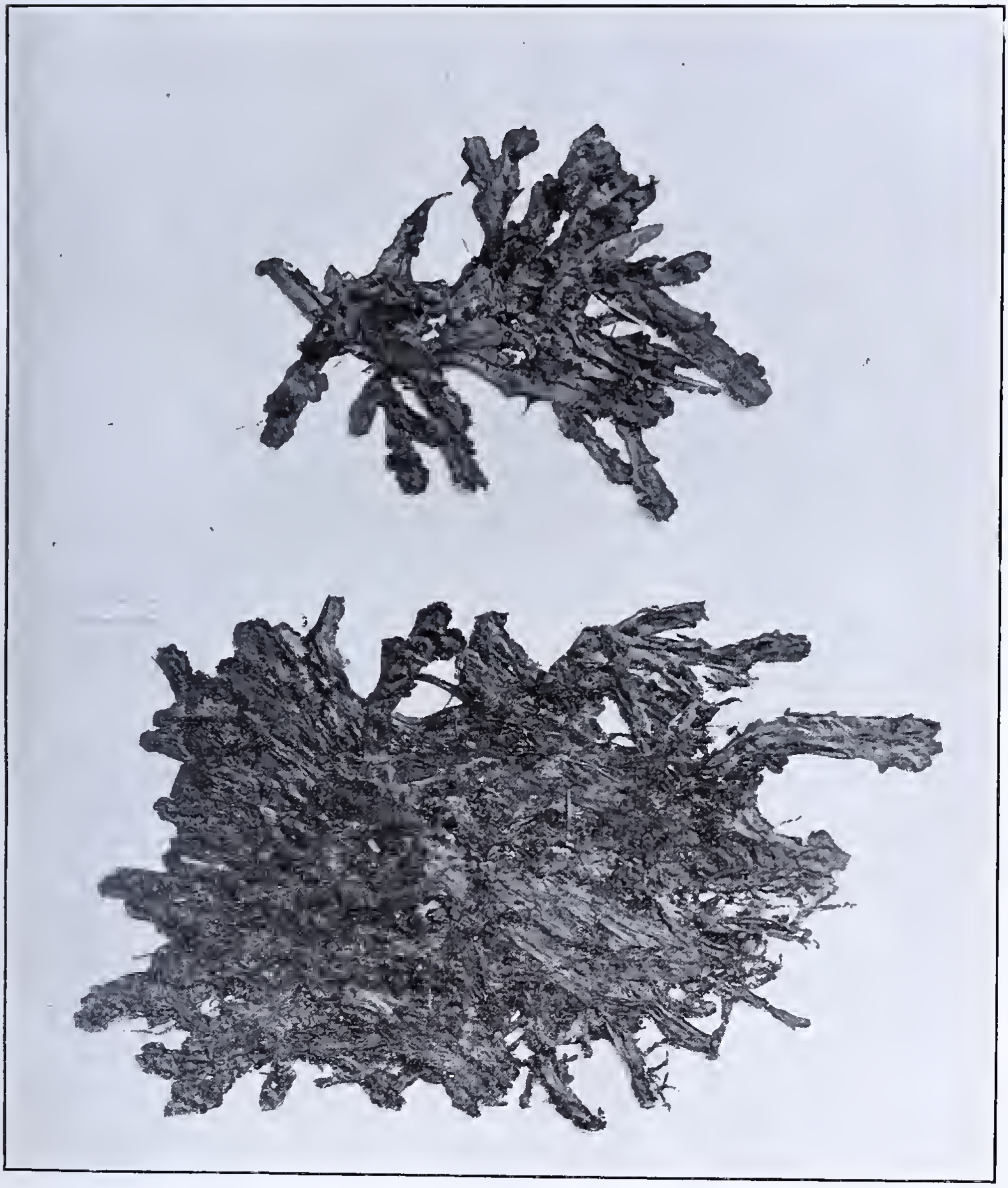


Thuidium delicatulum (L) Mitt.

Amblystegium Juratzkanum.



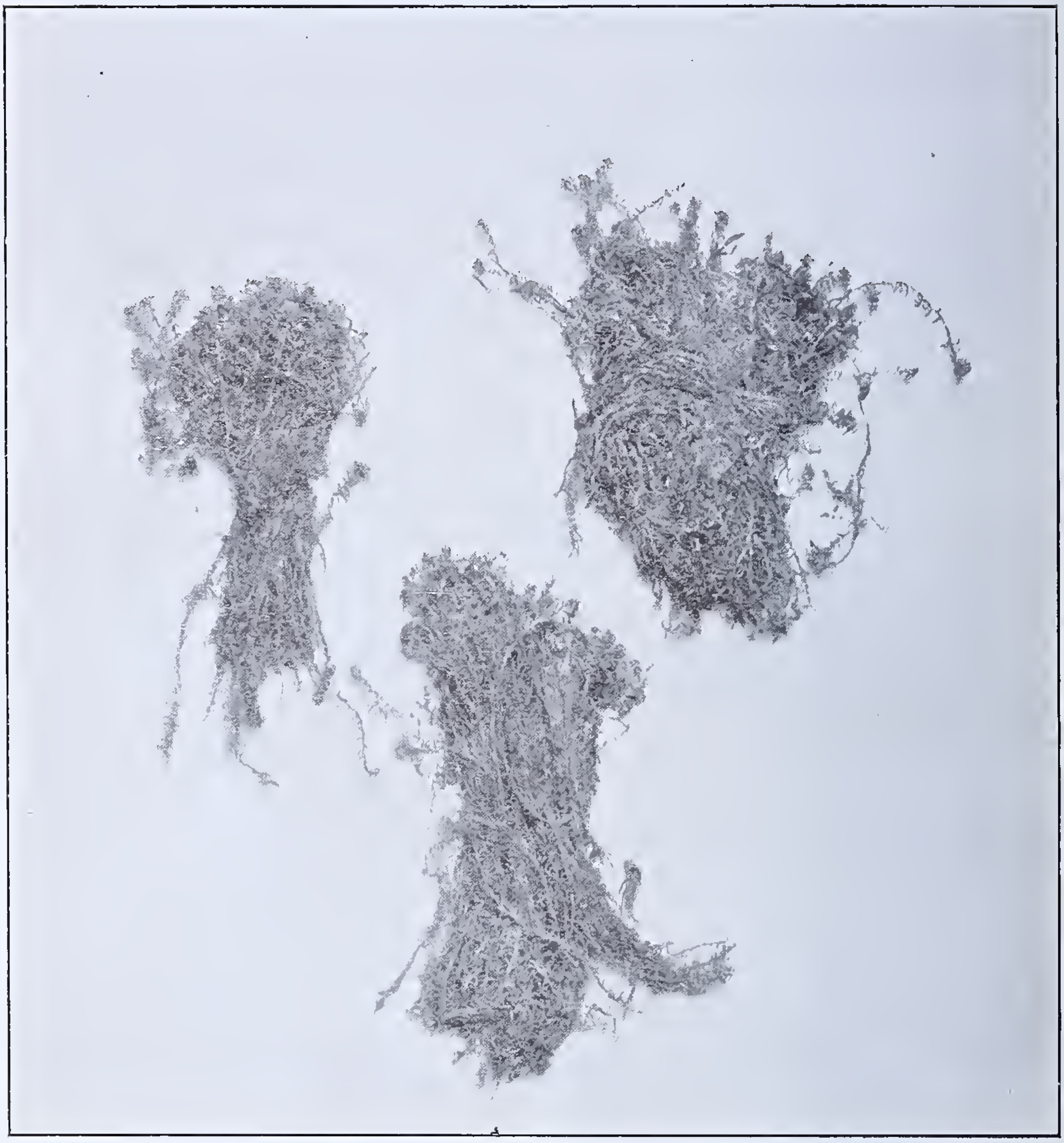
Mixture of three sterile species:—
Bryum bimum.
Tortula montana.
Ceratodon purpureus.



Marchantia polymorpha.

Empetrum nigrum (L).

Sphagnum tenellum, Pers.



Sphagnum capillaceum (Weiss) Schrank.

Sphagnum fuscum (Sch.) Klinggr. (Dark brown.) Sphagnum capillaceum (Weiss) Schrank var. tenellum (Schrimp) Andr. (Light red).

Dicranum Bergeri, Blandow.

The Peat Resources of Wisconsin

Recently the Wisconsin Geological and Natural History Survey published Bulletin No. 45 on "The Peat Resources of Wisconsin," by Frederick William Huels, which represents another valuable contribution to the literature on the peat deposits of this continent.

Peat is found in many parts of Wisconsin. It occurs in beds varying from 1 or 2 to over 20 feet in depth and from 10 to 30,000 or more acres in area. That near the surface is in an imperfect state of decomposition and is light, spongy, fibrous, and of yellow or light reddish brown color. Lower down the peat is more compact and darker colored. The lowest layers are almost black in color, pitchy and slippery and almost fiberless in structure.

These deposits examined are only a small part of those existing in the State and should be considered as showing repre sentative examples rather than the total number of deposits. Further deposits, perhaps equal in area and importance, exist, but it would have been impracticable to have more thoroughly investigated all of them with the time and funds available.

During recent years there have occurred a number of unusually dry periods and, as a result, the swamps and marshes of the State are much drier than formerly. Because of this condition there have been extensive and repeated marsh fires, as well as forest fires, which have consumed large amounts of moss and peat. Burning peat marshes may often be seen in the late summer or fall. The fires continue for weeks, large quantities of peat being consumed, and the consumption of fuel often continuing until considerable depths have been reached.

Hence, a destruction of peat resources takes place that is extremely rapid and out of all proportion to the length of time required for the peat to form. In many cases there is only a small amount of peat left in some of the swamps and marshes.

The largest and best peat deposits are located in the eastern half of the State. A fewer number of deposits, both smaller in area and poorer in quality, are found in the western half of the State. Perhaps the largest and more important deposits are located in the southeastern quarter of the State, and the deposits second in importance are found in the northeastern quarter. The northwestern quarter of the State has still fewer good peat marshes, and the southwestern quarter has practically none.

The value of the northern and western deposits of peat are lowered because they lie in a country as yet sparsely populated and largely undeveloped; hence there is practically no good

market for peat close at hand. Further, the gradual removal of timber and the consequent erosion of land in these sections cause more or less sand and clay to be washed into the lowlands, thus contaminating the peat and making its ash content high.

Wisconsin peat may be grouped broadly into three more or less distinct types, namely, (1) mosslike, partly decomposed peat, usually light colored; (2) claylike, muddy, thoroughly decomposed peat, usually dark brown or black in color; and (3) algal, or gray, soft, plastic, decomposed peat.

The mosslike peat, as its name implies, is made up principally of the remains of mosses. It usually has a coarse, spongy texture and has a gray or light brown color. The remains of plants from which it was formed are usually distinguishable in it and, on the whole, the peat is only slightly decomposed. It occurs characteristically in areas known as built-up or moist depression fillings. Sphagnum moss is the most common plant found upon deposits of this kind and, in addition, there will usually be found some sedges, shrubs like cassandra and andromeda, and cone-bearing plants. In deposits where sphagnum and the heaths predominate, the peat is usually very poorly decomposed, and is spongy and light brown. Other deposits, upon which conifer growths predominate, contain peat that is likely to be darker and more thoroughly decomposed but still fibrous, coarse, and brown.

The dark-brown or black, thoroughly decomposed type of peat is usually of a muddy, sticky and claylike consistency. It is compact and thoroughly decomposed and is most useful for commercial utilization as a fuel. Peat found underlying meadow marshes is usually of this variety. This type of peat is formed principally by acquatic seed plants such as pond lilies, bulrushes, sedges, grasses, etc., and accumulates in bodies of standing water, often called "filled basins" or "lake fillings."

While the two types of peat just described are most common and are sometimes supposed to be the only existing types, there is another product of plant decay which may be described as algal peat. Indeed, there is some controversy as to whether this product may be called peat at all. At the bottom of some of the bogs there will be found in the process of formation beds of soft, gray or light-colored, fine-grained, structureless peat of a cheesy consistency, which upon examination under a microscope is found to be composed largely of the remains of algal or cellular plants, in which root, stem and leaves are not distinguishable. The growths known as "pond-scums" belong to the algal plants that form this type of peat. Such algal peat was observed at the bottom of the deposits at Waupaca, Minocqua, Glidden and Sturgeon Bay. The origin and nature of this type of peat is still somewhat obscure but it is usually found at the bottom of

a deposit and below layers of brown or black and more thoroughly decomposed peat.

As far as the different kinds of deposits are concerned, it will be found that two or more of them may and often do occur together. Similarly, if the structure and composition of the peat are considered they will be found to vary considerably in different bogs or even in different parts of any one bog.

That Wisconsin peat can be manufactured into briquet form has been demonstrated to be a fact. Excellent briquets were made at Whitewater and Tomah. These resembled coal in appearance, were solid, compact, not at all brittle, clean and easily handled. They were made in two sizes, approximately disk shaped, one size being 2 inches in diameter and three-eights of an inch thick, the other size being slightly larger.

TABLE 1.—Proximate Analysis, Heating Value Etc., of Wisconsin Peat, Survey of 1903

Location of deposit	Deposit No.	Sample No.	As received, Moisture, percent.	Dry fuel				Combustible		
				Volatile matter, percent.	Fixed carbon, percent.	Ash, percent.	B. t. u. per pound	Volatile matter, percent.	Fixed carbon, percent.	B. t. u. per pound
Stoughton	1	1	69.7	63.3	25.3	11.4	9,320	71.5	28.5	10,500
Stoughton	1	2	65.2	63.1	24.5	12.4	8,980	72.0	28.0	10,260
Stoughton	1	3	87.0	62.4	26.5	11.1	8,929	70.4	29.8	10,000
Stoughton	1	4	74.4	59.3	20.5	20.2	6,190	74.4	25.7	7,760
Stoughton	1	5	85.3	63.3	23.6	13.1	8,570	73.9	26.1	9,880
Whitewater	2	1	69.4	38.4	16.9	44.7	6,040	69.5	30.6	10,900
Whitewater	2	2	85.5	60.4	27.8	11.8	9,440	68.5	31.6	10,700
Whitewater	2	3	82.8	58.2	26.6	15.2	9,040	68.7	31.4	10,650
Whitewater	2	4	*33.4	57.4	25.4	17.2	9,370	69.4	30.7	11,300
Whitewater	2	5	*14.0	59.7	29.4	10.9	8,600	67.0	33.0	9,695
Whitewater	3	1	83.0	52.2	28.3	19.5	8,060	64.9	35.2	10,000
Whitewater	3	2	82.9	62.0	28.7	9.3	8,370	68.4	31.6	9,250
Whitewater	3	3	80.7	57.2	27.0	15.8	8,600	68.0	32.0	10,200
Whitewater	4	1	81.1	55.7	25.1	19.2	7,920	69.0	31.1	9,800
Whitewater	4	2	80.7	53.1	32.3	14.6	8,490	62.3	37.8	9,900
Lake Beulah	5	1	*58.5	58.5	28.6	12.9	8,280	67.3	32.8	9,500
Lake Beulah	5	2	*14.9	56.7	30.9	12.4	8,870	64.7	35.2	10,100
Lake Beulah	5	3	83.5	59.3	27.5	13.2	8,870	68.1	31.9	10,200
Dousman	6	1	----	----	----	----	----	----	----	----
Madison	7	1	----	----	----	----	----	----	----	----
Glenbeulah	8	1	88.2	64.5	29.0	6.5	9,000	69.0	31.0	9,700
Glenbeulah	8	2	89.4	68.7	25.7	5.6	10,600	72.9	27.1	11,200
Glenbeulah	8	3	90.5	67.2	25.3	7.5	9,500	72.7	27.3	10,300
Glenbeulah	8	4	90.6	63.8	24.8	11.4	8,500	72.1	27.9	9,600
Glenbeulah	8	5	89.4	65.3	23.6	11.1	8,650	73.5	26.5	9,700
Medina	9	1	83.8	63.8	28.6	7.6	8,700	69.0	----	9,450
Medina	9	2	69.1	43.4	14.2	42.4	2,700	75.3	24.7	6,300
Med na	9	3	88.8	59.8	29.4	10.8	8,400	67.1	32.9	9,500
Medina	9	4	83.4	61.7	30.0	8.3	9,800	67.2	32.8	10,600
Medina	9	5	83 5	56.2	29.7	14.1	8,600	65.5	34.5	9,900
Medina	9	6	80.0	62.6	19.3	18.1	7,300	76.5	23.5	8,900
Fond du Lac	10	1	83.1	61.8	26.8	11.4	8,800	69.9	30.1	9,900
Fond du Lac	10	2	81.4	60.6	24.0	15.4	8,800	71.7	28.3	10,400
Fond du Lac	10	3	79.5	43.7	29.8	26.5	4,800	59.5	40.5	6,600
Fond du Lac	10	4	80.1	55.4	27.5	17.1	6,900	66.9	33.1	8,300
Fond du Lac	10	5	84.0	61.1	29.0	9.9	8,700	68.0	32.0	9,600
Fond du Lac	10	6	88.9	70.5	21.8	7.7	10,300	76.5	23.5	11,100
Chester	11	1	79.0	55.3	28.4	16.3	7,300	66.2	33.8	8,770
Chester	11	2	77.7	48.0	23.3	28.7	7,600	66.4	33.6	10,600

TABLE 1.—Proximate Analysis, Heating Value Etc., of Wisconsin Peat, Survey of 1903

Location of deposit	Deposit No.	Sample No.	As received, Moisture, percent.	Dry fuel				Combustible		
				Volatile matter, percent.	Fixed carbon, percent.	Ash, percent.	B. t. u. per pound	Volatile matter, percent.	Fixed carbon, percent.	B. t. u. per pound
Chester	11	3	78.6	52.7	25.4	21.9	7,100	67.5	32.5	9,100
Chester	11	4	77.9	47.9	23.8	28.3	6,700	66.9	33.1	9,400
Chester	11	5	82.0	58.1	17.8	24.1	6,870	76.6	23.4	9 000
Mendota	12	1	86.4	64.1	25.1	10.8	8,700	72.8	27.2	9,800
Mendota	12	2	86.6	60.1	25.5	14.4	8,400	70.4	29.6	9,800
Mendota	12	3	86.5	57.7	26.4	15.9	8,100	68.6	31.4	9,600
Mendota	12	4	85.8	56.9	25.9	17.2	7,800	68.7	31.3	9,500
Mendota	12	5	85.4	54.0	31.8	14.2	7,800	63.0	37.0	9,200
Mendota	12	6	88.6	63.1	27.6	9.3	9,200	69.6	30.4	10,100
Markesan	13	1	85.1	60.8	30.1	9.1	9,500	67.1	32.9	10,400
Markesan	13	2	67.0	45 9	7.1	47.0				
Marshall	14	1	*18.6	60.9	27.9	11.2	9,000	68.8	31.4	10,200
Rhinelander	15	1	89.3	66.2	28.3	5.5	10,600	70.1	29.9	11,300
Rhinelander	15	2	91.4	66.3	27.3	6.4	9,600	70.9	29.1	10,300
Rhinelander	15	3	89.4	71.3	22.8	5.9	9,200	75.8	24.2	9,800
Rhinelander	15	4	90.7	66.0	28.5	5.5	9,960	69.9	30.1	10,500
Rhinelander	16	1								
Rhinelander	17	1								

* Sample was partly air-dried before analysis, and figure does not, therefore, indicate the moisture content of sample as taken from the bog.

TABLE 2.—Proximate Analysis, Heating Value Etc., of Wisconsin Peat, Survey of 1908

			Air dried						As received						Dry fuel				
Location of deposit	Deposit No.	Air-drying loss, percent.	Moisture percent.	Volatile matter, percent.	Fixed carbon, percent.	Ash, percent.	B. t. u. per pound	Sulphur, percent.	Moisture, percent.	Volatile matter, percent.	Fixed carbon, percent.	Ash, percent.	B. t. u. per pound	Sulphur, percent.	Volatile matter, percent.	Fixed carbon, percent.	Ash, percent.	B. t. u. per pound	Sulphur, percent.
Madison	301	61.50	9.26	47.18	17.89	25.67	6,250	.42	65.07	18.16	6.89	9.88	2,407	.16	51.99	19.73	28.28	6,890	.45
Madison	301	82.00	8.60						*83.55										
Madison	302	68.50	8.99	50.82	21.42	18.77	6,943	.38	71.33	16.01	6.75	5.91	2,187	.12	55.84	23.55	20.61	7,628	.42
Madison	302	84.30	6.92						*85.39										
Fond du Lac	303B	73.80	11.99	51.03	21.75	15.23	7,169	.66	76.94	13.37	5.70	3.99	1,879	.17	57.98	24.72	17.30	8,149	.74
Fond du Lac	303B	85.00	7.72						*86.16										
Fond du Lac	303A	6.60	9.95	48.14	25.14	16.77	7,468	.79	15.89	44.96	23.49	15.66	6,975	.74	53.45	27.93	18.62	8,293	.88
Waupaca	304	19.40	6.95	54.23	23.44	15.38	7,614	.37	25.00	43.71	18.89	12.40	6,136	.30	58.29	25.18	16.53	8,181	.40
Waupaca	304	85.60	6.90						*86.59										
Waupaca	305	13.00	6.62	55.31	13.63	24.44	6,970		18.76	48.12	11.86	21.26	6,064		59.23	14.60	26.17	7,465	
Waupaca	305	94.90	7.64						*95.29										
Kiel	306	16.40	7.70	48.28	16.0[illegible]	27.9[illegible]	6,[illegible]07	1.51	22.84	40.45	13.37	23.34	5,107	1.26	52.42	17.33	30.25	6,619	1.63
Kiel	306	83.60	7.74						*84.82										
Kiel	307	28.40	6.82	52.30	21.42	19.45	7,253	1.51	33.28	37.45	15.34	13.39	5,195	1.08	56.13	22.99	20.88	7,787	1.62
Kiel	308	20.40	7.79	53.04	20.8[illegible]	18.32	7,119	.82	26.60	42.22	16.60	14.58	5,606	.65	57.52	22.62	19.86	7,[illegible]20	.89
Kiel	308	86.90	9.25						*88.11										
Kiel	309		8.22	58.07	23.21	10.59	8,032	.64	20.43	50.35	20.12	9.10	6,964	.55	63.28	25.28	11.44	8,753	.69
Kiel	309	90.30	7.79						*91.06										
Bloomer	310	72.90	11.76	41.80	15.30	31.14	5,503	.28	76.09	11.33	4.14	8.44	1,490	.08	47.39	17.31	35.30	6,233	.33
Bloomer	310	80.10	9.15						*81.92										
Bloomer	311	75.80	10.35	49.26	24.74	1[illegible].6[illegible]	7,929	.21	78.30	11.92	5.99	3.79	1,919	.05	54.93	27.60	17.47	8,842	.23
Bloomer	311	82.20	7.67						*83.57										
Ashland	312	45.30	6.82	26.69	6.38	60.11	2,984	.24	49.03	14.60	3.49	32.88	1,633	.13	28.64	6.85	64.51	3,202	.26
Ashland	312	61.30	4.57	22.00	5.64	67.19		.18	*63.07	8.75	2.18	26.00		.07	23.69	5.91	70.40		.19
Hayward	313	9.00	10.21	50.77	25.06	13.96	7,866	.26	18.[illegible]9	46.20	22.81	12.70	7,159	.24	56.54	27.92	15.54	8,761	.29
Hayward	313	90.80	6.66						*91.41										
Hayward	314	11.30	7.71	51.13	20.07	21.09	7,411	.39	18.14	45.35	17.80	18.71	6,[illegible]74	.35	55.40	21.74	22.86	8,028	.43
Hayward	314	91.10	3.93						*91.45										
New Auburn	315	4.90	7.66	53.55	25.48	13.31	8,222	.20	12.18	50.93	24.23	12.66	7,819	.19	57.99	27.59	14.42	8,905	.22
New Auburn	315	92.50	4.95						*92.87										
Cameron	316	9.30	5.21	60.08	26.78	7.93	8,716	.28	14.03	54.49	24.29	7.19	7,906	.25	63.38	28.26	8.36	9,196	.29
Cameron	316	90.50	7.22						*91.19										
Ladysmith	317	7.80	3.85	54.00	20.98	21.17	7,646	.24	11.35	49.79	19.34	19.52	7,051	.22	56.16	21.82	22.02	7,952	.25

TABLE 2.—Proximate Analysis, Heating Value Etc., of Wisconsin Peat. Survey of 1908.

Location of deposit	Air dried								As received						Dry fuel				
	Deposit No.	Air-drying loss, percent.	Moisture percent.	Volatile matter, percent.	Fixed carbon, percent.	Ash, percent.	B. t. u. per pound	Sulphur, percent.	Moisture, percent.	Volatile matter, percent.	Fixed carbon, percent.	Ash, percent.	B. t. u. per pound	Sulphur, percent.	Volatile matter, percent.	Fixed carbon, percent.	Ash, percent.	B. t. u. per pound	Sulphur, percent.
Ladysmith	317	88.50	5.31						*89.11										
Heafford Jct	318	10.10	4.07	53.63	20.44	21.86	7,722	.23	13.76	48.21	18.38	19.65	6,943	.21	55.90	21.31	22.79	8,051	.24
Heafford Jct	318	93.70	5 08						*94.02										
Minocqua	319	15.10	5.72	50.08	20.82	23.38	7,456	.28	19.96	42.52	17.67	19.85	6,331	.24	53.12	22.08	24.80	7,909	.30
Minocqua	319	83.20	4.12						*83.89										
Minocqua	320	9.20	4.58	51.92	18.82	24.68	7,236	.50	13.36	47.14	17.09	22 41	6,570	.45	54.41	19.72	25.87	7,583	.52
Minocqua	320	92.50	4.36						*92.83										
Lac du Flambeau	321	10.80	2.68	53.52	22.84	20.96	8,417	.16	13.19	47.47	20 37	18.70	7,508	.14	54 99	23.47	21.54	8,649	.16
Lac du Flambeau	321	83.70	5.02						*84.52										
Powell	322	11 40	6.56	53.04	25.32	15.08	7,627	.89	17.21	46.99	22.44	13 36	6,757	.79	56.76	27.10	16.14	8 161	.95
Powell	322	87.50	6.29						*88.29										
Glidden	323	9 00	4.62	58.33	25.76	11.29	8,723	.22	13.20	58.03	23.45	10.27	7,938	.20	61.15	27.02	11.83	9,146	.23
Glidden	323	91.80	6.33						*92.32										
Park Falls	324	8.00	3.99	42.81	18.95	34.25	6,291	.30	11.67	39.39	17.43	31.51	5,787	.28	44.59	19.74	25.67	6,552	.32
Park Falls	324	71.10	5.63						*72.73										
Kewaunee	325	6.10	8.96	53.94	23.60	13.50	7,290	.47	14.51	50.65	22.16	12.68	6,845	.44	59.25	25.92	14.83	8 006	.51
Kewaunee	325	86.70	7.88						*87.85										
Algoma	326	3 50	7.51	38.52	15.19	33.78	5,445	.26	10.75	37.17	14.66	37.42	5,254	.25	41.65	16.42	41.93	5,886	.28
Algoma	326	67.60	7.63						*70.07										
Sturgeon Bay	327	6.30	9.01	54.73	16.20	20.06	7,186	.77	14.74	51.28	15.18	18.80	6,734	.72	60.15	17.80	22.05	7,898	.84
Sturgeon Bay	327	91.40	8.77						92.15										
Peshtigo	328	75.10	5.05	43 29	18.69	32.95	6 012	.66	76.36	10.78	4.66	8 20	1,498	.16	45.60	19.71	34.69	6 334	.68
Pembine	329	6 80	9.25	50.60	23.15	17.00	7,112	1.51	15.42	47.16	21.58	15 84	6,628	1.41	55.75	25.52	18.73	7,835	1.67
Pembine	329	82.80	6.80						*83.97										
Gagen	330	10.30	5.71	59.19	26.13	8.97	8,856	.21	15.42	53.09	23.44	8.05	7,943	.19	62.77	27.71	9.52	9,391	.22
Gagen	330	86.40	5.74						*87.18										
Eagle River	331	11.20	5.21	60.14	24.06	10.59	8,869	.26	15.83	53.40	21.37	9.40	7,875	.23	63.44	25.39	11.17	9,356	.27
Eagle River	331	85.70	5.13						*86.43										
Antigo	332	78.60	7.67	43.04	19.47	29.82	5,870	.60	80.24	9.21	4 17	6.38	1,255	.13	46.61	21.10	32.29	6 358	.66
Mountain	333	12.90	7.95	54.46	25.47	12.12	7,191	.69	19.82	47.43	22.19	10.56	6,264	.60	59.15	27.68	13.17	7,812	.75
Mountain	333	86.60	7.24						*87.57										

*Sample represented raw peat with moisture content as collected directly from marsh.

To interpret the data of the tables, the following explanation is needed. The samples collected in the 1903 survey were inclosed in air-tight bottles as soon as collected in the field and were then shipped to the laboratory in this condition. These samples were then analyzed in the laboratory and the results are given in Table 1 in the column headed "As received, Moisture." This column, therefore, shows the moisture contained in the raw peat as collected from the bog. Five of the samples, however, which are indicated in Table 1 with an asterisk (*) were not raw peat samples, but were partly or wholly air-dried before analysis. Consequently, these five samples cannot be considered in determining the amount of moisture in the raw heat as found in the bog. Neglecting these five, and considering the remaining 28 specimens, we find the results for 1903 shown in Table 3, column 2.

A similar plan was followed in the 1908 survey. Partly air-dried samples and raw samples are included in Table 2. But the samples of raw peat then collected are indicated by a dagger (†) in Table 2. Considering these 30 samples we find results for 1908 as shown in Table 3, column 3.

A general average of the two surveys is also given in column 4 of Table 3, following.

Here it will be seen that the percentage of moisture in the raw peat of Wisconsin, as collected from the bog, ranges from approximately 64 to 93 per cent and that the general average is about 84.5 per cent.

Table 3—Moisture in raw peat.

	1903* Per cent	1908† Per cent	Average 1903-1908 Per cent
Maximum	91.4	95.29	93.3
Minimum	65.2	63.07	64.1
Average	82.7	86.31	84.5

Raw peat, taken indoors and exposed to room conditions, can be almost thoroughly dried. Handled in this manner, the moisture content of the Wisconsin samples of 1908 ranged from 2.5 to 12 per cent. (See Table 2, column headed "Air Dried Moisture.") But in speaking of "air-dried peat," we rarely mean peat dried in this way. By that term we mean, rather, peat, which, after having been dug, is exposed to out-of-door conditions, either unprotected from the elements or protected from them by sheds or otherwise. And where the term "air-dried" is used in the present section, the latter meaning is intended.

* 48 samples of 1903 survey included, except those marked * in Table 1, for reasons explained.

† 30 samples of 1908 survey included, marked † in Table 2, for reasons explained.

Several air-dried samples of Wisconsin peat were obtained and analyzed. This moisture content, together with a brief explanation of the conditions to which they were exposed, etc., are given in Table 4, following.

The maximum moisture content was 58.5 per cent; the minimum, 14.0 per cent; the average 26.9 per cent. It is seen that the moisture content of air-dried peat depends in a large measure upon the conditions of weather to which it is exposed.

Table 4—Moisture content in air-dried Wisconsin peat.

Location	Deposit	Sample	Air dried; moisture; per cent
Whitewater	2	4	33.4

Remark—Sample was taken from some of the underground, artificially dried, uncompressed product at Whitewater factory. It had been standing for some months.

Location	Deposit	Sample	Air dried; moisture; per cent
Whitewater	2	5	14.0

Remark—Sample was taken from some of the compressed commercial products made in 1902 at the Whitewater factory. Said to have been stored in a rather damp place.

Location	Deposit	Sample	Air dried; moisture; per cent
Lake Beulah	5	1	58.5

Remark—Sample taken from some air-dried, pulverized peat, taken out by P. J. Buckley, for experimental purposes. Had been piled in open air for five or six months. Was covered with snow when sample was taken.

Location	Deposit	Sample	Air dried; moisture; per cent
Lake Beulah	5	2	14.9

Remark—Sample taken from some pulverized, dried peat, prepared by P. J. Buckley for experimental purposes. Dried artificially in open air and stored in sheds in marsh.

Location	Deposit	Sample	Air dried; moisture; per cent
Marshall	14	1	18.6

Remark—This sample was collected by Prof. Baldwin of Marshall. It was taken from the surface and sent in to be tested. It was evidently part air-dried en route.

Location	Deposit	Sample	Air dried; moisture; per cent
Fond-du-Lac	303A	....	15.89

Remark—Some of the machined and unfinished peat, taken from the storage bins in the abandoned peat factory. Bins covered, but open to the outdoor air. Had lain several years.

Location	Deposit	Sample	Air dried; moisture; per cent
Kiel	307	....	33.28

Remark—Sample dug from deposit by Reinhardt Thiessen, of Kiel, and had lain on the ground in the swamp for about one year.

Average of above 7 samples....................26.9

Data upon volatile matter, fixed carbon, ash, and heating value will be given for the dry and moisture-free condition of the peat. This is done for the reason that Tables 1 and 2 both contain results reduced to these terms and, for the further reason, that fuels can be compared upon this basis more readily.

Table 5, following, gives the minimum, maximum, and average percentages of volatile matter in Wisconsin peat. It will be observed that the volatile constituents comprise 56.4 per cent of the peat in its dry or moisture-free condition.

Table 5—Volatile matter in Wisconsin peat, for dry or moisture-free fuel.

	1903 Per cent	1908 Per cent	Average 1903-1908 Per cent
Minimum	38.4	23.69	....
Maximum	71.3	63.44	....
Average	59.0	53.8	56.4

The volatile matter makes up that portion of the fuel which is driven off by the application of heat. It consists principally of hydrocarbons or complex compounds of hydrogen and carbon chemically combined in various proportions, such as benzene, ethylene, acetylene, methane or marsh gas, etc. Other gases, like oxygen (O) and nitrogen (N), in small quantities, are also a part of the volatile matter. The volatile matters are the chief gaseous products resulting from the distillation of peat in retorts.

That part of the carbon in a fuel which is not volatile, is called "fixed carbon." It is that carbon remaining in the fuel after the volatile matter has been driven off. The amount of fixed carbon is important as, in a measure, it indicates the value of the coke formed from peat after distillation. (See Table 6.)

Table 6—Fixed carbon in Wisconsin peat, for dry and moisture-free fuel.

	1903 Per cent	1908 Per cent	Average 1903-1908 Per cent
Minimum	7.1	5.91	....
Maximum	32.3	27.93	....
Average	25.8	22.2	24.0

Volatile matter and fixed carbon constitute the combustible materials in a fuel. The average amounts of these found in peat samples mentioned in the preceding paragraphs are 56.4 per cent for the volatile matter and 24.0 per cent for the fixed carbon, and the sum of these, 80.4 per cent, is the combustible in the dry fuel.

Ash content is determined by subtracting the sum of the combustible materials from the total weight of dry peat. The total combustible was found to be 80.4 per cent; therefore, the difference between 100.0 per cent and 80.4 per cent gives the ash content, amounting to 19.6 per cent.

An average of the ash percentage given in Tables 1 and 2 shows a value of 19.2 per cent. This affords a reasonably close check. The following table is also appended.

Table 2—Ash in Wisconsin peat, dry and moisture-free fuel.

	1903 Per cent	1908 Per cent	Average 1903-1908 Per cent
Minimum	5.5	8.36	....
Maximum	47.0	70.40	....
Average	14.6	23.9	19.2

Sulphur determinations were made out for the 1908 samples only. The percentages as found are: Minimum, 0.16 per cent; maximum, 1.67 per cent; and average, 0.55 per cent.

The value of a fuel depends largely upon the amount of heat that it will generate upon combustion. Heating value is measured and expressed in thermal units per pound of fuel. The thermal unit most commonly used is the British thermal unit, or B.t.u., and this is the amount of heat that will raise the temperature of 1 pound of water 1 degree Fahrenheit.

The average heating value of the Wisconsin samples is found to be 8,070 B.t.u. per pound of dry fuel. See Table 8 for other data on heating value.

Table 8—Heating value of Wisconsin peat, for dry and moisture-free fuel.

	1903 B.t.u.	1908 B.t.u.	Average 1903-1908 B.t.u.
Minimum	3,700	3,202	......
Maximum	10,600	9,391	......
Average	8,390	7,390	8,070

The several minimum, maximum, and average figures of the items from the proximate analysis of Wisconsin peat may be summarized as in Table 9.

Table 9—Minimum, maximum, and average data for proximate analysis of Wisconsin peat, dry and moisture-free fuel.

		1903	1908	Average 1903-1908
Volatile matter, per cent	Minimum	38.4	23.69	......
	Maximum	71.3	63.44	......
	Average	59.0	53.8	56.4
Fixed carbon, per cent	Minimum	7.1	5.91	......
	Maximum	32.3	27.93	......
	Average	25.8	22.2	24.0
Ash, per cent	Minimum	5.5	8.36	......
	Maximum	47.0	70.40	......
	Average	14.5	23.9	19.2
Sulphur, per cent	Minimum	....	0.16	......
	Maximum	....	1.67	......
	Average	....	0.55	0.55
B.t.u. per pound	Minimum	3,700	3,202	......
	Maximum	10,600	9,391	......
	Average	8,390	7,750	8,070

It is rather difficult to make even an approximate statement of the total quantity of peat available in Wisconsin for commercial purposes. No complete data are at hand for the determination of this amount.

Professor T. C. Chamberlin in his reports on the geology of Wisconsin estimates the available quantity of dried peat in the State to be 50 million tons. This estimate is based upon data gathered during an investigation of the geology of the State. But Chamberlin's work relative to the peat deposits was limited and this estimate is probably much too low.

F. H. King, in the "Handbook of Northern Wisconsin," states that "while there are but few very large areas continuously covered by these soils, yet the aggregate amount of them in northern and central Wisconsin is very large, probably not less than 1 to 1.5 million acres." This estimate probably was not intended to include the peat deposits of southern Wisconsin.

L. S. Smith, in "Water Powers of Wisconsin," writes, "Many of the northern swamps are underlain by vast beds of peat, while all have a thick covering of moss and humus." "The aggregate amount is probably not less than 2,500,000 to 2,800,000 acres."

No official survey of the quantity of peat land in Wisconsin has ever been made, but there are somewhere between two and three million acres.

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